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Marion I. Jackson

PROCEEDINGS

of the

Indiana Academy *of* Science

Founded December 29, 1885

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Volume 72
1962

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Richard A. Laubengayer, Editor
Wabash College
Crawfordsville, Indiana

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Spring Meeting
May 18-19
Spring Mill State Park

Fall Meeting
October 18-20
Evansville College

Published at Indianapolis, Indiana
1963

1. The permanent address of the Academy is the Indiana State Library, 140 N. Senate Ave., Indianapolis 4, Indiana.

2. **Instructions for Authors** appear at end of this volume, P.

3. **Exchanges.** Items sent in exchange for the Proceedings and correspondence concerning exchange arrangements should be addressed:

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4. **Proceedings** may be purchased through the State Library at $5.00 per volume.

5. **Reprints of technical papers** can often be secured from the authors. They cannot be supplied by the State Library nor by the officers of the Academy.

6. The Constitution and By-Laws reprinted from v. 62 and the Membership List reprinted from v. 67, are available to members upon application to the Secretary. Necrologies reprinted from the various volumes can be supplied relatives and friends of deceased members by the Secretary.

7. Officers whose names and addresses are not known to correspondents may be addressed care the State Library. The address of the editor of the present volume is Biology Department, Wabash College, Crawfordsville, Ind.

Papers published in the Proceedings of the Indiana Academy of Science are abstracted or indexed in appropriate services listed here:

Annotated Bibliography of Economic Geology

Bibliography of Agriculture

Bibliography of North American Geology

Biological Abstracts

Chemical Abstracts

Chemisches Zentralblatt

Current Geographical Publications

Geological Abstracts

Mathematics Reviews

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Program: Chairman, R. H. Coleman, Evansville College; M. S. Casler, R. T. Dufford, D. W. Dunham, L. E. Weller.

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Resolutions: Chairman, H. R. Youse, DePauw University; S. D. Gerking.

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Indiana Junior Academy of Science: State Sponsor, H. H. Michaud, Purdue University; R. Weber, Sister Suzanne, V. C. Cripe, Helen Reed, D. Winslow.

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Indiana Science Talent Search: Director, Sears Crowell, Indiana University; L. H. Baldinger, J. M. Egar, R. L. Henry, C. A. Markle.

Special Constitution Revision Committee: Chairman, Ray T. Everly, Purdue University; P. Weatherwax, W. A. Daily.

SPRING MEETING

Spring Mill State Park

MINUTES OF THE EXECUTIVE COMMITTEE MEETING

May 18, 1962

President Harry G. Day called the Executive Committee meeting to order at 4:30 P.M. in the Inn.

Treasurer Kermit Carlson presented a report showing the beginning balances in the various budgeted accounts as of January 1, 1962, the receipts and disbursements, and the new balances as of May 15, 1962. The total balance in the Academy Accounts was $4,830.30. He also presented a report on the status of the two N.S.F. grant accounts showing a balance as of May 15 of $6,348.46. The treasurers report was accepted.

The chairman of the Youth Activities Committee reported on the Junior Activities of the Academy and pointed out the high cost of the Science Fair due to the fact that the National Science Fair was held at Seattle. He pointed out that the next National Science Fair will be held in New Mexico and noted the need to reassess the raising of funds to support the Science Fair activity. This year each regional fair was assessed $500.00 for two students and two teachers. About $5,000.00 was raised from contributions and other sources. Indiana did well at the National Fair, receiving two first places and a number of lesser awards, which was one of the best records in the nation.

Mr. Klinge announced that Howard Michaud has asked to be relieved of his duties in the Youth Activities program. Dr. Willig will continue to serve as state director of the Science Fair program. Mr. Klinge noted that Indiana also had a fine record in the Science Talent Search.

Editor Richard A. Laubengayer reported that galley proofs were being sent to contributors and that an early distribution of the Proceedings was anticipated. He pointed out that Volume 71 would also include a ten-year index and would be bound in red. He pointed out once more the need for Divisional Chairmen to follow the regulations concerning abstracts and manuscripts, which if followed, would ease the burden of the Editor.

Fellows Committee chairman Ray Everly presented an extensive report outlining proposed procedures for nominating fellows including qualifications in addition to those now mentioned in the constitution, and a form for nominations. Several constitutional changes were recommended to augment the recommendations of the committee. It was also proposed that the Academy have prepared a Certificate of Election as a Fellow. The report of the committee was accepted and filed by the secretary under the heading Fellows in the Academy files.

The following proposed change in the constitution was approved for presentation at the business meeting in the evening and for final reading at the annual meeting in the fall:

Article II, Section 3, Paragraph 1. Members who are actively engaged in productive scientific research with recognized standing in their field of endeavor, who have been members of this Academy in good standing for the past three years, and have demonstrated evidence of interest in the Academy, and/or have given dedicated service to encouraging youth in science in our colleges, universities, and secondary schools, upon recommendation by the Committee on Fellows, may be elected a Fellow of the Academy.

It was moved that the following paragraph change in the constitution be approved and presented to the fall meeting for adoption:

Article 3, Paragraph 2. Nominations for Fellows should be made on the approved form and signed by two Fellows of the Academy. All nominations must be in the hands of the Chairman of the Committee on Fellows not later than six weeks prior to the convening of the Executive Committee at the annual Fall meeting of the Academy. A three-fourths favorable vote of the members of the Executive Committee present shall constitute election as a Fellow.

A motion carried to amend the proposal to read that "A three-fourths favorable vote of the members of the Executive Committee present shall recommend the nominees to the assembly of the Academy for election."

The amended motion then was approved.

Invitations Committee chairman R. E. Siverly reported that Goshen College had invited the Academy to meet on their campus for the 1963 Fall meetings. The report of the committee was accepted and it was decided to accept the Goshen College invitation if details for the meetings can be worked out satisfactorily.

Press Secretary Frank N. Young reported that notices of the current meetings had been sent out to the various news media and that a report had been passed along to the Library. He noted that good radio and television coverage had been provided for the Fall meeting at Terre Haute.

Howard H. Michaud reported that in the Visiting Scientists Program 88 visitors from 20 colleges had received 254 assignments and that a fine response had been received from both high schools and visitors.

Paul Klinge pointed out the various curriculum studies underway and moved that the Program Chairman for the Fall meeting make plans for and issue suggestions to the sectional chairmen to include plans for curriculum studies in their programs. The motion carried.

Miss Nelle Coats reported that copies of serials received by the Academy had been distributed at the Junior Science Assembly. A report to the Lilly Endowment on the use of funds received from the endowment had been made.

A motion carried instructing the president to appoint a committee to study the constitution and by-laws and to make a report at the Fall Executive Committee meeting.

Twenty-two members were in attendance at the Executive Committee meeting.

The meeting was adjourned.

MINUTES OF THE DINNER MEETING

May 18, 1962

Following dinner in the main dining room of the Spring Mill Inn the evening business meeting was called to order by President Harry G. Day at 8:00 P.M.

The president introduced the current officers and the divisional chairmen present.

The proposed changes in the constitution and by-laws relative to elections of fellows as approved in the Executive Committee meeting were presented by the secretary for the first reading. The proposed amendments to the constitution are:

Article II, Sec. 3, Paragraph 1. Members who are actively engaged in productive scientific research with recognized standing in their field of endeavor, who have been members of this Academy in good standing for the past three years, and have demonstrated interest in the Academy, and/or have given dedicated service to encouraging youth in sciences in our colleges, universities, and secondary schools, upon recommendation by the Committee on Fellows, may be elected a Fellow of the Academy.

Article II, Sec. 3, Paragraph 2. Nominations for Fellows should be made on the approved form and signed by two Fellows of the Academy. All nominations must be in the hands of the chairman of the Committee on Fellows not later than six weeks prior to the convening of the Executive Committee at the annual Fall meeting of the Academy. A three-fourths favorable vote of the members of the Executive Committee present shall recommend the nominees to the assembly of the Academy for election.

Howard R. Youse, chairman of the resolutions committee presented a resolution which carried expressing the appreciation of the Academy to Mr. James C. Tusing, manager of Spring Mill Inn and his staff for all the arrangements and our thanks to the program chairman, speakers, and leaders of the field trips for their services.

Sixteen senior membership applications and one Junior Club application were approved.

Following the business meeting Dr. Glenn Black presented a most interesting illustrated talk with colored slides to illustrate the work on the Angel Mounds near Newburgh, Indiana which was followed by a lively discussion.

Dr. R. E. Siverly of Ball State Teachers College presented an interesting study of the life cycle of a mosquito amply illustrated by colored slides.

Ralph Coleman, chairman of the program committee announced that the field trips on Saturday morning would be conducted by J. Dan Webster of Hanover (birds), James Maysilles of Hanover (botany), Duncan McGregor of the Department of Conservation, Geological Survey (geology and soils), and Jack Munsee and William B. Hopp of Indiana State College (zoology).

William W. Bloom, Secretary

Approved 10-18-62

MINUTES OF THE EXECUTIVE COMMITTEE MEETING

EVANSVILLE COLLEGE, Evansville, Indiana
October 18, 1962

The Executive Committee meeting of the Indiana Academy of Science was held on October 18, 1962 in the Club Room of the Student Union of Evansville College. The meeting was called to order by the president, Harry G. Day, at 7:40 C.D.T.

The minutes of the Spring meeting of the executive committee and the general sessions held on May 18, 1962 at Spring Mill State Park were read by the secretary and approved as read.

Treasurer—Dr. Kermit Carlson presented the treasurer's report showing the balance in the various State Academy accounts as of January 1, the receipts and disbursements and the present balances as of September 30, 1962. The January 1 balance plus the 1962 receipts at this time amounted to $21,545.42. Disbursements totaled $14,761.95 with a current balance of $6,783.47. The three N.S.F. grant accounts showed a total of $25,210.52 for the January 1 balance plus receipts during 1962. Disbursements of N.S.F. funds totaled $12,913.85 for a balance in N.S.F. accounts of $12,296.67.

The complete financial report for the entire year of 1962 is as follows:

FINANCIAL REPORT OF THE INDIANA ACADEMY OF SCIENCE

January 1, 1962 thru December 31, 1962

Acct. No.	*Account Name*	*Balance Jan. 1*	*Receipts Jan.-Dec.*	*Disbursed Jan.-Dec.*	*Balance Surplus*
1.	Indiana Academy of Science	1,417.02	4,486.15	2,504.39	3,398.78
2.	Jr. Academy of Science	141.19	—	109.03	32.16
3.	Academy funds designated for Research Grants	600.00	750.00	310.00	1,040.00
4.	John Shepard Wright Mem. Lib.	994.53	996.05	1,222.52	768.06
5.	Science Fair *(1961 deficit)*	-390.68	13,234.00	12,270.17	963.83
					—390.68
					573.15
6.	Science Talent Search *(1961 deficit)*	-248.58	4,200.00	1,627.00	2,573.00
					—248.58
					2,324.42
A.	*Totals in State Accounts*	2,513.48	23,666.20	18,043.11	8,136.57
7.	NSF G-17042				
	Visiting Scientists Program	14,900.72	—	12,764.75	—
	Returned to Nat. Science Found.			2,135.97	
8.	NSF G-22464				
	Visiting Scientists Program	—	17,150.00	4,583.42	12,566.58
B.	*Totals in Federal Accounts*	14,900.72	17,150.00	19,484.14	12,566.58
	A & B Total State and Federal	17,414.20	40,816.20	37,527.25	20,703.15

Bank Balances: First Federal Savings and Loan Assn. 10,150.00
Farmers State Bank 10,553.15
20,703.15

Audited March 7, 1963 Kermit H. Carlson, Treasurer

In our opinion these accounts are accurate and correct.

Auditing Committee: R. J. Hanson
Clarence Dineen

Editor—Richard A. Laubengayer: Volume 71 of the Proceedings will be ready for distribution shortly. The delay has been due to the publishing of the ten-year index. Twelve hundred hard bound copies and six hundred paper bound copies have been ordered from the printer. The editor urged that all contributors of manuscripts and abstracts follow the rules set down in the proceedings.

Program—Ralph Coleman: Everything is in good order for the Friday sessions. All members of the academy are invited to the social hour preceeding the general session. A member of the Evansville College staff is to be in each divisional meeting and will be available for assistance as needed.

Press Secretary—Frank N. Young: Dr. Young reported that news releases had been sent out to the various news media and that the local newspapers and television and radio stations would cover the meetings. He pointed out that lack of some abstracts and delay in preparing the programs hampered news coverage.

Trustees of the Academy Foundation—William A. Daily: The beginning cash balance in the foundations funds plus receipts as of September 30, 1962 amounted to $1,354.53. Disbursements were $336.72, leaving a cash balance of $1,017.81. As of September 30 the principal cash balance was $619.84 but $500.00 of this has been invested in a treasury bond. The total carrying value of bonds and stocks held by the foundation as of September 30, 1962 was $14,563.92.

Relation of Academy to the State—William A. Daily: Mr. Daily reported that the committee had requested an increase of $1,500.00 per annum for a total of $5,500.00 requested per annum as a subsidy for publishing the Proceedings of the Academy.

In order to meet the additional expense of publishing the ten-year index in Volume 71 now at the printers a motion carried to authorize William A. Daily to seek the needed funds to pay the additional cost.

Research Grants Committee—T. J. Yuncker: Dr. Yuncker reported that $460.00 had been allowed as follows during the past year:

> Dr. C. L. Bieber, DePauw University, Dept. of Geology, $100.00 for assistance in studying and mapping certain facies changes in the Mansfield Sandstone formation from Turkey Run to the Ohio River.
>
> Mrs. Faye K. Daily, Dept. of Botany, Butler University, $100.00 to aid in photographic and other work in her continuing study of fossil Charophytes.
>
> Mr. Charles Hall, Manual Training High School, Indianapolis, $100.00 to assist in expenses in his continuing survey of the algal flora of Putnam County, Indiana.
>
> Prof. A. A. Smucker, Dept. of Chemistry, Goshen College, $160.00 for the hire of an assistant used in connection with research on the physiology of fungi spore germination.

Biological Survey Committee—C. A. Markle: Reports have been submitted on work on flora and fauna of Indiana, indicating whether in progress, completed but not published, or published. The publications list and summary of work in progress follows:

Publications of 1961-1962
Dealing with the Flora and Fauna of Indiana

Algae:

1. Daily, Fay Kenoyer, 1961. Glacial and Post-Glacial Charophytes from New York and Indiana. Butler Univ. Bot. Stud., Vol. XIV (1) : 39-71.
2. Daily, William A., 1962. Some Algae of the Cabin Creek Raised Bog. Proc. of Ind. Acad. of Sci., Vol. **71** in press.
3. Hall, Charles R., 1962, Algae of Putnam County, Indiana. Proc. of Ind. Acad. of Sci., Vol. **71** in press.
4. Reimer, Charles W., 1962. Some Aspects of the Diatom Flora of Cabin Creek Raised Bog, Randolph County, Indiana. Proc. of Ind. Acad. of Sci., Vol. **71** in press.
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3. ————, 1962. The High Bridge Foray of the American Bryological Society. Bryologist 65(1) : 51-54.
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2. Petty, R. O., and A. A. Lindsey, 1962. Hoot Woods, a Relic of Virgin Forest in Owen County, Indiana. Proc. of Ind. Acad. of Sci., Vol. **71** in press.

Annelida:

1. Joyner, James J. and Paul Harmon, 1962. Investigations of the Burrows and Oscillative Behavior Therein of *Lumbricus terrestris*. Proc. of Ind. Acad. of Sci., Vol. **71** in press.

Insecta:

1. Chandler, Leland, 1962. *Agapostemon nasotus* (Hymenoptera: Halictidae) in the United States. Ann. Ent. Soc. Amer. **55**(4) : 481.
2. ————, 1961. Interspecific Competition in *Osmia lignaria* Say—*O. cordata* Robt. Nesting Associations. Proc. North Central Branch, Ent. Soc. Amer. **16**: 18-19.
3. ————, 1961. Notes on the Species of *Psaenythia* (Hymenoptera: Andrenidae) in the Eastern United States. J. Kansas Ent. Soc. **35**(3) : 313-314.
4. ————, 1962. The Nocturnal Bee, *Sphecodogastra texana* (Cr.), at Light Traps. Proc. of Ind. Acad. of Sci. Vol. **71** in press.
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6. Dishner, Gayla H. and Ray T. Everly, 1962. Greenhouse Studies on the Resistance of Corn and Barley to the Corn Leaf Aphid. Proc. of Ind. Acad. of Sci. Vol. **71** in press.

7. Dobson, R. C., 1962. Horn Fly Control on Beef Cattle by the Use of Cable Rubbers. Jour. of Economic Entomology in press.
8. Dobson, R. C. and D. A. Huber, 1961. Control of Face Flies (*Musca autumnalis*) on Beef Cattle in Indiana. Jour. Econ. Ent. Vol. 54(3): 434-436.
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Aves:

1. Mumford, Russell E. and Val Nolan, Jr., 1961. Albino Field Sparrow Found. Indiana Audubon Quarterly, 39:28.
2. Nolan, Val, Jr., 1962. Reproduction and Success of Birds in a Deciduous Scrub Habitat. Ecology, in press.
3. ————, 1962. The Sexual Nexus in the Prairie Warbler. Proceedings XIII International Ornithological Congress. In press.
4. ————, 1962. The Swaying Display of the Red-eyed and Other Vireos. The Condor 64: 273-276.
5. Nolan, Val, Jr. and Raymond Schneider, 1962. A Catbird Helper at a House Wren Nest. Wilson Bulletin 74: 183-184.
6. Nolan, Val, Jr. and David P. Wooldridge, 1962. Food Habits and Feeding Behavior of the White-eyed Vireo. Wilson Bulletin 74:68-73.

Mammalia:

1. Cope, James B., 1962. A Study of the *Myotis* of Wyandotte Cave, Crawford County, Indiana. Paper given at American Society of Mammalogists.

Work in Progress or Completed, but not yet Published, Dealing with the Flora and Fauna of Indiana

Bryophyta:

1. Stevenson, Forrest. Building an Herbarium of Liverworts and Mosses.

2. Welch, Winona H. Bryophytes of Cabin Creek Raised Bog. Proceedings of Indiana Academy of Science, 1963.
3. —————, Studies in Indiana Bryophytes XIII. Proceedings of Indiana Academy of Science, 1963.

Vascular Plants:

1. Heiser, C. B., Jr. Pollination in *Magnolia*.
2. Markle, Carrolle A. and Norman Richardson. Contributions to the Flora of Wayne County, Indiana.

Annelida:

1. Joyner, James J. Earthworms of Indiana.

Insecta and Arachnida:

1. Chandler, Leland. An Evaluation of the Community Ordination Method Using Winter Stonefly Populations. In progress, as Purdue AES Project No. 200 Sub. 12.
2. —————, Interspecfic Competition in *Osmia coerulescens* (L.) *O. albiventris* Cr. Nesting Associations. North Central Branch, Ent. Soc. Amer., Purdue Univ. 1963.
3. Chappell, Robert G. and L. Chandler. The Ecology of Winter Stoneflies in the Columbus, Indiana Area. Proc. Ind. Acad. Sci.
4. Dobson, R. C. 1. Cattle Grub Control with Systemics.
    2. Cattle Grub Populations in Indiana.
    3. Face Fly Control Measures.
    4. Face Fly—Pink Eye Relationships.
    5. Horn Fly Reactions to Hormone Treated Calves.
5. Everly, Ray T. 1. Control of Angoumois Grain Moth Field Investigation in Popcorn.
    2. Investigations of the Inheritance of Attractiveness of Dent Corn to the European Corn Borer Moths in Single, Tree-way, and Double-cross Dent Hybrids.
    3. Planting Date Effect on Insect Infestation and Damage in Dent Corn.
6. Gould, George E. 1. Control of Corn Billbug, Wireworms and Other Soil Insects.
    2. Control of Cucumber Beetles.
    3. Control of Insects Attacking Peppermint and Spearmint.
    4. Japanese Beetle, Its Potential Danger to Agricultural Crops in Indiana.
7. Hardwick, Paul F. and L. Chandler. The Mortality of *Ceratina metallica* Smith during Hibernation.
8. Hazeltine, William E. and L. Chandler. A Preliminary Atlas for the Identification of Female Bumblebees, Based on the Sixth Metasomal Sternite.
9. Hershey, Stephen C. and Ray T. Everly. Effect of Stage of Corn Plant Development in the Greenhouse on Survival of the Corn Leaf Aphid. To be presented at the 1962 meeting of the North Central Br. of the Ent. Soc. Amer. in Minneapolis.
10. Schuder, Donald L. 1. Control of the Leafroller *Tortrix pallorana* Rob. on Pine Trees.
    2. The Ecololgy and Control of the Mimosa Webworms *Homadaula albizziae* Grote, in Indiana.
    3. The Biology and Control of Scale Insects on Ornamental Trees, Shrubs and Vines.
    4. The Biology and Control of Borers of Woody Ornamentals.
    5. Biology and Control of the Zimmerman Pine Moth, *Dioryctria zimmermani* Grote.

   6. Biology and Control of Mites on Woody Ornamentals.

11. Siverly, R. E. Taxonomic and Distributional Study of Mosquitoes in Indiana.

12. Ward, Gertrude L. 1. Insects of the Whitewater Valley. 2. Spiders of Indiana.

13. Wood, Vida G. The Effect of X-Radiation of Longevity in *Drosophila melanogaster*. In progress, AEC Grant.

Aves:

1. Cooper, Robert H. Occurrence of the Whistling Swan (Cygnus columbianus L.) in Delaware County, Indiana. To be given at the Indiana Academy of Science Autumn Meeting, 1962.
2. Cope, James B. Bird Migration Studies.
3. Nolan, Val, Jr. Long Term Monographic Studies of Prairie Warbler, White-eyed Vireo, Bell's Vireo, Cardinal, Indigo Bunting, Slate-colored Junco, Goldfinch——All from Banded Populations, Bloomington.

Mammalia:

1. Cope, James B. Bats of Indiana.

Miscellaneous Plant and Animal Group:

1. Laubengayer, Richard A. Inventory of Plant Groups in Allee Memorial Woods, Parke County, Indiana.
2. Williams, Eliot C., Jr. Quantitative and Population Studies of Certain Insect, Reptile, Mammal and other Faunal Groups in Allee Memorial Woods, Parke County, Indiana.

Fellows Committee—Ray T. Everly: The following names were presented as recommendations for election as fellows of the Academy: Marion T. Hall, Botany and Plant Taxonomy; V. J. Shiner, Jr., Chemistry; Marvin Carmack, Chemistry; E. V. Walter, Entomology; Harold Morrison, Entomology; George D. Lovell, Psychology; James P. Egan, Psychology; John F. Pelton, Plant Taxonomy; A. J. Ohlrogge, Soil Science; Stanley A. Barber, Soil Science.

A motion carried to recommend the names submitted by the committee to the assembly of the Academy for election as fellows.

The committee also made a number of suggestions to enhance the status of Fellow in the Academy. They reported that the certificate of election had been prepared and recommended that they be issued to fellows elected previous to 1962. A number of other suggestions are to be incorporated in proposed constitutional changes. The committee reported was accepted.

Invitations Committee—R. E. Siverly: The chairman reported that the invitation of Goshen College to hold the fall meetings in 1963 at Goshen College had been accepted. He reported that Wabash College had indicated interest in hosting the 1964 meeting and that Ball State College may be in a position to host the 1965 meetings.

Library Committee—Mrs. Lois Burton: Mrs. Burton presented the report of the library committee. Throughout the year special attention has been given to the acquisition of missing issues of publications, a program which has had a gratifying response, perhaps indicating better circumstances among the foreign agencies with which the Wright Library corresponds. Exchange arrangements were made with additional organizations and twenty-three new titles have been received. Two hundred nineteen volumes of serial material were prepared for binding as directed by the Academy's Budget Committee at a cost of $996.05. Copies of the checklist of the Library's *Titles and Holdings of Periodical Literature*, prepared in 1959 but still reasonably useful were distributed at the latest Junior Scientists Assembly at Indianapolis. The following items were purchased with Lilly Endowment Inc. funds: International Association of Physical Oceanography. Publications Scientifique. nos. 14-20; Cabot Foundation. Publications nos. 4-5; India. Dept. of Agriculture. Memoirs. Botanical series. v. 1-19, 1906-1913. At the suggestion of Mrs. John Shepard Wright several handsomely illustrated volumes on birds of various countries are on order to be charged to the Wright Fund.

Representative to the AAAS Council—Willis Johnson: Our representative reported that he had attended the meetings of the council last Dec. 27 and 30. No business pertaining especially to the State Academies was considered but a summary report of the highlights of the council sessions were presented to the executive committee.

Youth Activities Committee—Paul Klinge: The chairman reported on the activities of the various groups, the scope and importance of the youth activities in the Academy and the status of the work in Indiana as compared to other states. He reported that the incorporation of the activities sponsored by this committee into the State Academy program was being used as a model by other state groups. He pointed up the need for proper identification and recognition of the youth activities by the Academy as important in securing needed support for the programs.

Science Fairs—In the absence of Leslie Willig who served as State Director, Paul Klinge reported on the scope of the 1962 activities. There were twelve regional fairs in Indiana and the director arranged details for transporting 24 student winners and their sponsors to Seattle for the National Science Fair. The total cost for the fair program was $12,270.17, much of which Dr. Willig raised himself.

Junior Academy—Howard Michaud: Dr. Michaud reported that approximately 230 students, sponsors and guests attended the 1961 meeting at Indiana State College. Sixteen exhibits and 24 papers were presented. Stephen Ridgway of Central Jr.-Sr. High School, South Bend received the best boy award and Patricia Kira of George Washington High School, Indianapolis, and Margaret Weir of John Adams High School, South Bend tied for the best girl award. Rosemary de Beeze, Immaculate Conception Academy, Oldenburg, won the bacteriology award. The 1962 meeting will be held in Evansville on October 20.

Visiting Scientists Program—Howard Michaud: As director of the program Dr. Michaud reported that 88 scientists from 20 Indiana colleges and universities made 238 visits. The number of visits by special areas were: biology, 79; chemistry, 47; physics, 41; mathematics, 37; entomology, 12; geology and geography, 12; bacteriology, 4; bionucleonics, 3; astronomy, 2; general science, 1. A total of $2,534.50 in grants from $2.97 to a maximum of $100.00 was made to 54 students for projects.

Science Talent Search—Sears Crowell: As chairman of the committee, Dr. Crowell reported on the results of the Science Talent Search in Indiana. Indiana has ranked very high in national competition. The Tri Kappas have assumed full responsibility for the support of the program.

Indiana School and College Committee on Mathematics—J. C. Polley: Dr. Polley reported that the committee promoted activities intended to stimulate interest in the improvement of the mathematics program in schools and colleges in Indiana. It supported local meetings of mathematics teachers held at various centers during the year and a special program devoted to a discussion of geometry in the school mathematics curriculum and in the undergraduate mathematics program. The committee also collaborated with a committee of Indiana actuaries representing the Society of Actuaries in managing the National Mathematics Contest for high schools in Indiana. Plaques were presented to the highest ranking high schools and individual prizes were awarded to the top 25 individuals. The National Science Foundation has granted the amount of $4,000.00 to support the program of the committee for the academic year 1962-63.

It was announced that William Kessell of Indiana State College would serve as director of the Visiting Scientists Program in place of Dr. Howard H. Michaud, who asked to be relieved of this duty.

Dr. Ray Everly offered the following motion which carried: Because of these deficiencies in the present constitution and by-laws, a special committee of three members be appointed by the incoming president for 1963 to redraft these documents and submit the new constitution to the Executive Committee for consideration at the fall meeting of 1963.

The following constitutional and by-laws changes were presented for consideration:

In the second sentence of Article III of the constitution, the word *President-Elect* be substituted for *Vice-President,* and that the words *Membership Secretary* be added after the word *Secretary.* The sentence as amended, would then read: "They (the officers) shall consist of a President, a President-Elect, Divisional Chairman, a Secretary, a Membership Secretary, a Treasurer, an Editor and a Press Secretary."

Section 2 of Article I of the by-laws be replaced by the following: "Section 2. President-Elect. The President-Elect shall assume the office of President immediately following the last business session of the fall meeting of the Academy in the year in which he has served as President-Elect. During his term as President-Elect, he shall discharge all the duties of the chief executive officer in the absence of the President. He shall familiarize himself with all the operations of the Academy and prepare lists of committee appointments prior to assuming the office of President."

The following be adopted as Section 5 of Article I of the by-laws, and that the numbering of the present sections 5 through 7 be changed to 6 through 8: "Section 5. Membership Secretary. The Membership Secretary shall assume all duties concerned with the maintenance of membership lists and shall be prepared at all times to provide officers, committee chairmen, and sectional chairmen with lists necessary to their operations. He shall develop such forms as are necessary for keeping proper records of membership. He shall, at regular intervals, secure from the Secretary and the Treasurer the information necessary for maintaining these lists."

Section (m) of Article II of the by-laws, which has been amended since its original adoption, be rewritten to read as follows: "Section (m). Committee on Fellows. Membership of the Committee on Fellows shall be limited to one representative from each division of the membership of the Academy. The term of office shall be three years. Beginning in 1963 with the divisions listed in alphabetical order, one-third of the members shall be appointed to serve for three years, one-third for two years, and the remaining group for one year. In subsequent years, these divisional representatives shall be replaced when their terms expire with others elected to serve for three years. Representatives of new divisions which shall be organized in the future shall be added to the group with the smallest number of appointees, and their terms of office shall expire with the terms of the others of that group. The chairman of the committee shall have had at least one year of service on the committee."

The following new section be added to Article II of the by-laws: Section (n). Committee on constitution and by-laws. The duties of this committee shall be to justify all executive actions, to keep the constitution and by-laws up-to-date, and give advice and assistance in the preparation of proposed amendments. The committee shall consist of three members in rotating order, each serving as chairman the last year of his term. The chairman of the committee shall be a member ex-officio of the Council of the Academy.

It was moved and carried that the proposed changes in the constitution be distributed in the spring mailing prior to the spring meeting.

Thirty-one members of the executive committee were in attendance.

The meeting adjourned at 11:00 P. M., C.D.T.

WILLIAM W. BLOOM, Secretary

Approved 10-19-62

MINUTES OF THE GENERAL SESSION

EVANSVILLE COLLEGE, October 19, 1962

The general session was called to order by President Harry G. Day who then introduced Dr. Melvin Hyde, President of Evansville College, who welcomed the members of the Academy to Evansville and to the campus.

The minutes of the Executive Committee were read and approved.

The proposed amendments to the constitution and by-laws of the Academy which had been approved in the Executive Committee meeting were reread as published in the record of the Executive Committee meeting and approved by the assembly. These amendments will be read for the second time at the general sessions of the Spring meeting in 1963 for final adoption.

Dr. William E. Edington presented a short biographical sketch of members who had died during the year, the sketches published in another section of the Proceedings. The deceased members were John Orville Cottingham, Jesse James Galloway, Waldo Lee McAtee, Robert John Sheehan, Jesse Robertson Singleton, Paris Buell Stockdale, Richard Lockwood Webb, Charles Alexander Deppe, and G. Wyatt H. Powell.

Dr. Richard T. Arnold, president, Mead Johnson Research Center, and formerly chairman of the Department of Chemistry, University of Minnesota, presented a most stimulating address on "The Everlasting Fight Against Professional Obsolescence."

The meeting was adjourned for the beginning of the sectional meetings.

The sectional meetings began at 11:00 A. M. and continued until completion of the divisional programs with a noon recess for lunch. Following completion of the divisional programs an open house was held at the Angel Mounds Site with a tour of the area conducted by Dr. Glenn A. Black.

The annual dinner meeting was held in the Great Hall of the Student Union Building of Evansville College.

Vice President Howard H. Michaud presided at the meeting and introduced the officers at the speaker's table. Visitors from New Jersey, Illinois, and New Zealand were introduced to the assembly.

Dr. Ralph E. Cleland, reporting for the nominations committee, announced the divisional elections held during the sectional meetings. The chairman elected for the 1963 meetings were: Anthropology, Richard Johnson, Indiana Historical Society, Evansville; Bacteriology, Richard Smith, Miles Ames Research Laboratory, Elkhart; Botany, J. H. Maysilles, Hanover College; Chemistry, Keith White, Hanover College; Entomology, George E. Marshall, Experimental Horticultural Orchard, Mitchell; Geology and Geography, Robert Johnson, Purdue University; History of Science, A. T. Guard, Purdue University; Mathematics, Ernst Snapper, Indiana University; Physics, Paul Bender, Goshen College; Plant Taxonomy, Joseph Hennen, Indiana State College; Psychology, William Martin, Purdue University; Soil Science, Gerald E. Wilcox, Purdue University; Zoology, William Eberly, Manchester College.

A slate of officers was presented, followed by a motion to close the nominations and to elect the slate by acclamation. The motion carried and the officers elected for 1963 are as follows: President, Howard H. Michaud, Purdue University; Vice President, Edward Haenisch, Wabash College; Secretary, William W. Bloom, Valparaiso University; Treasurer, Kermit H. Carlson, Valparaiso University; Editor, Richard A. Laubengayer, Wabash College; Press Secretary, Frank N. Young, Indiana University; Committee of Bonding Trustees, Scott McCoy, Technical High School, Indianapolis; Frank J. Welcher, Indiana University, Adult Education Center, Indianapolis; Research Grants Committee, John Fraser Hart, Indiana University.

Howard R. Youse, Chairman of the Resolutions Committee presented the following resolutions which were approved:

Resolved: That the Academy members here assembled express their sincere thanks to Evansville College through Dr. Melvin W. Hyde, President of the College for all the courtesies which have been shown the Academy during the meetings. Special appreciation and thanks are due to Professor R. H. Coleman and his committee in charge of the program and local arrangements for the splendid and efficient manner in which all arrangements were made for the conduction of the business of the Academy and the comfort and convenience of the entire membership.

Resolved: That the Academy members here assembled express their sincere appreciation to Howard H. Michaud, who has been sponsor of the Indiana Junior Academy of Science for the past sixteen years and chairman of the Visiting Scientists program of the Academy for the past four years, in which capacity he has given outstanding leadership in science education in the State of Indiana.

Special appreciation and thanks are also due Ralph Lefler for his twelve years of service as chairman of the Science Talent Search. Through his efforts and leadership many young scientists have received recognition and scholarships that have enabled them to continue their science training and to take their place in our science community.

In the absence of Dr. Louis DeLanney, Dr. Willis Johnson reported for the membership committee. He reported that a tentative list of thirty-seven full members, twenty student members and two Junior clubs had applied for membership. The applications were approved.

Dr. Michaud called attention to the meetings of the Junior Academy on Saturday and urged every member to attend some of the meetings if possible.

The formal business meeting was adjourned and Dr. Michaud introduced President Harry G. Day who presented his presidential address on "The Nutritional Significance of Trace Inorganic Elements." The text of the address is published as a part of the Proceedings.

WILLIAM W. BLOOM, Secretary

NEW MEMBERS—1962

Adler, Edwin F., 301 Winfield St., Greenfield, Ind.	Bo
Ahrendt, Mrs. Martha, 1331 N. Chester St., Indianapolis 1, Ind.	G
Akalan, Dr. Ilahn, Ziraat, Fakultesi Toprak Kursusu, Ankara, Turkey	SS
Alexander, Archie, R. R. 7, Crawfordsville, Ind.	E
Amstutz, David W., Walnut Grove Trl. Ct. No. 94, Bloomington, Ind.	G
Amstutz, Frank E., R. R. 1, Spencerville, Ind.	G
Annis, Mr. James Frederick, 200 E. Southern Dr., Bloomington, Ind.	A
Arnold, Dr. Richard T., Mead Johnson Research Center, Evansville, Ind.	C
Aughenbaugh, Nolan B., R. R. 10, Lafayette, Ind.	
Baiamonte, Vernon D., 906 Clarksdale Dr., Muncie, Ind.	C
Bart, Miss Carol, 508½ N. Lincoln Ave., Bloomington, Ind.	A
Bast, Mr. Leonard J., Jr., Redbud Hill Apts., No. 603, Bloomington, Ind.	A
Bedwell, Max, 206 E. Mulberry St., Salem, Ind.	Z, Bo
Benjaminov, Benjamin, Rose Polytechnic Institute, Terre Haute, Ind.	C
Billman, D. C., Jr., Mgr. of Quality Control, Chas. Pfizer Co., Vigo Plant, Terre Haute, Ind.	C
Blair, Dr. Byron O., Agronomy Dept., Purdue Univ., Lafayette, Ind.	G, SS
Bosstick, Maurice, 1917 N. 13th St., Terre Haute, Ind.	Z
Brown, M. Alan, Franklin College, Franklin, Ind.	C
Carney, Thomas P., 740 S. Alabama St., Indianapolis, Ind.	C
Cleveland, John Herbert, 2201 E. 7th, Bloomington, Ind.	G
Craig, Prof. Edwin Charles, Physics Dept., Ball St. College, Muncie, Ind.	Ph
Cropp, Mr. C. Bruce, 11313 Old State Rd., Evansville, Ind.	Ba
Davis, Mr. John Baldwin, 1419 Potomac Ave., Lafayette, Ind.	E
Decker, Mr. Johnathan E., 507 Ringo Drive, Brazil, Ind.	G
Dobbins, Mr. David R., 798 E. Jefferson St., Franklin, Ind.	Bo, Z
Feldman, Dr. Herman, Indiana Univ., Gary campus, 3400 Broadway, Gary, Ind.	Ps
Forbes, Mrs. Olive E., 132 First Ave., Oakland City, Ind.	C
Gabbard, Miss Karen Lee, 2635 N. 11th St., Terre Haute, Ind.	Ba
Garnier, Prof. Benjamin J., Dept. of Geography, I. U., Bloomington, Ind.	G
Ghate, Mr. Ashok V., Dept. of Entomology, Agric. Hall, Purdue Univ., Lafayette, Ind.	E
Haffley, Mr. Philip G., 2706 Milton Dr., Bloomington, Ind.	C
Hall, Mr. Donald W., 102 Andrew Place, W. Lafayette, Ind.	E

Hamon, Dr. J. Hill, Dept. of Zoology, Indiana State College, Terre Haute, Ind. Z

Hardwick, Mr. Paul F., R. R. 4, Bedford, Ind. E

Harris, Franklin, 205 Morris Hall, Wabash College, Crawfordsville, Ind. Bo

Harrison, Mr. Edward F., 1650 E. Walnut St., Evansville, Ind. Ba

Haslanger, Martin W. (Mrs.) 20980 New Rd., Lakeville, Ind. Bo, G

Hatchett, Mr. Jimmy H., A.E.S. Bldg., Ento. Res. Div., Purdue Univ., Lafayette, Ind. E

Heniser, Mr. Virgil, 121 Jordan Hall, Indiana Univ., Bloomington, Ind. C

Hicks, Dr. R. Lowell, Science Dept., Arlington H. S., 4825 N. Arlington, Indianapolis 26, Ind. C

Hoffman, Warren E., Chem. Dept., Indiana Technical College, Fort Wayne, Ind. C

Hufford, Terry L., 3920 S. Meridian St., Apt. 15, Indianapolis, Ind. Bo

Hull, Dr. Clarence, Science Dept., Indiana State College, Terre Haute, Ind. C

Hunt, Mr. Ariel C., Foreman, Yards and Grounds, R. R. 7, Schaffer Rd., Evansville, Ind. Bo, E, SS

Johnson, Charles B., R. R. 2, Otterbein, Ind. SS

Johnson, Dr. Robert B., School of Civil Engineering, Purdue Univ., Lafayette, Ind. G

Kane, Henry Edward, Dept. of Science, Ball St. Teachers College, Muncie, Ind. G

Knowles, William W., Geography Dept., I. U., Bloomington, Ind. G

Kohlstaedt, Dr. Kenneth G., M. D., Executive Director Med. Research, % Eli Lilly Co., 740 S. Alabama St., Indianapolis 6, Ind.

Kowitz, William T., Geog. Dept., Valparaiso Univ., Valparaiso, Ind. G

Kutlich, Eleanor Svea, 9601 Petersburg Rd., Evansville 7, Ind. Bo

Lantz, Mr. Larry, 1118 E. State St., Ft. Wayne 3, Ind. Bo, PT

Larsen, Dr. Aubrey A., Mead Johnson Research Center, Evansville, Ind. C

Mann, Dr. Robert L., Lilly Research Labs., Eli Lilly and Co., Indianapolis, Ind. C

Mannering, Jerry V., Lilly Hall of Science-Agronomy Dept., Purdue Univ., Lafayette, Ind. SS

Martin, William E., Head, Dept. Child Development, Purdue Univ., Lafayette, Ind. Ps

McElhinney, Mrs. Margaret, 3816 Brook Dr., Muncie, Ind. Bo

Meisenheimer, Mr. John L., Chemistry Dept., Indiana Univ., Bloomington, Ind. C

Moussa, Dr. Moufied A., 613 State Office Bldg., Division of Entomology, Indianapolis 9, Ind. E

Mueller, Wayne P., Evansville College, Evansville 14, Ind. Z

Murray, Mr. Harry L., Mead Johnson and Co., Evansville, Ind. Ba

Neumann, Mr. Erik Arnulf, 704 S. Rose Ave., Bloomington, Ind. A

Olson, Mr. Tamlin C., 2501 Iroquois Tr., Lafayette, Ind. SS

Pemberton, Woodrow, 844 Jackson Ave., Evansville 13, Ind. Ph

Post, Mr. Donald F., Agronomy Dept., Purdue Univ., Lafayette, Ind. SS

Powell, Mr. Richard L., 417 E. Allen St., Bloomington, Ind. G

Prickett, Dr. Paul S., Mead Johnson and Co., Evansville, Ind. Ba

Redfern, Mr. Robert E., Sr., 1118 Chestnut St., Vincennes, Ind. E

Reed, Walter L. and Esther B., 500 Barton Ave., Terre Haute, Ind. G

Ritter, Mr. David L., 2861 Harts Run Rd., Allison Park, Penn. Z

Robinson, Prof. Kenneth S., Oakland City College, Oakland City, Ind. Ph

Rothwell, Frederick M., 104 S. 17th St., Terre Haute, Ind. Bo

Sapaula, Miss Crispina C., 346 S. Grant St., Bloomington, Ind. A

Siders, Miss Marlyn, R. R. 2, Macy, Ind. Z, Bo

Skomp, Mr. David C., 1123 Euclid Ave., Marion, Ind. A

Smith, Mr. Jerry D., Box 136, Roachdale, Ind. Z

Sparks, Phillip D., R. R. 3, Terre Haute, Ind. Bo

Sutton, Traver C., Physics Dept., Evansville College, Evansville, Ind. Ph

Tamar, Dr. Henry, Division of Science, Indiana State College, Terre Haute, Ind. Z

Terman, Dr. C. Richard, Biology Dept., Taylor Univ., Upland, Ind. Z

Tweedell, Dr. Kenyon S., Dept. of Biology, Univ. of Notre Dame, Notre Dame, Ind. Z

Wade, Claude F., 210½ Main, Whiteland, Ind. E

Waller, Dr. Coy W., Mead Johnson and Co., Evansville, Ind. C

Welder, Dr. George W., Ball State Teachers College, Muncie, Ind. Ba, Z

Wertenberger, Dr. Grace E., Physiology Dept., Indiana Univ., Bloomington, Ind.

Wheaton, Prof. Howell N., Agron. Dept., Life Science Bldg., Purdue Univ., W. Lafayette, Ind. SS

Whitaker, Dr. John O., Jr., Dept. of Science, Indiana State College, Terre Haute, Ind. Z

Zachary, Mr. Alvin L., Agronomy Dept., Life Science Bldg., Purdue Univ., Lafayette, Ind. SS

Zehring, Miss Conie Sue, R. R. 1, Bunker Hill, Ind. E

JUNIOR ACADEMY CLUBS

Fulton Jr. High School Science Club, 10th and Girl School Road, Indianapolis, Ind.

Manuel High School Saturday Morning Science Club, Emmerich Manuel High School, 2405 Madison Ave., Indianapolis 25, Ind.

INDIANA JUNIOR ACADEMY OF SCIENCE

OFFICERS FOR 1962

President: Craig Johnson, Washington High School, Indianapolis
Vice President: Janet Holscher, Saint Rose Academy, Vincennes
Secretary: Kathryn Crider, North Central High School, Indianapolis

MEMBERS OF THE COUNCIL

Robert Weber, Chairman, Fort Wayne (1958-1962); Sister Suzanne, Vincennes (1959-1963); V. C. Cripe, South Bend (1960-1964); Don R. Winslow, Bloomington (1961-1965); Helen Reed, Lebanon (1962-1966).

PROGRAM OF THE THIRTIETH ANNUAL MEETING

OCTOBER 20, 1962

Engineering Science Building, Evansville College, Evansville, Indiana.

8:30-10:00 A. M. Registration and Placement of Exhibits, Room 203.

10:00-11:00 A. M. Conferences in Science and Mathematics by faculty representatives of Evansville College.

Officers of the Junior Academy: l. to r., Vice-President, Janet Holscher, Saint Rose Academy, Vincennes; President, Craig Johnson, Washington High School, Indianapolis; Secretary, Kathryn Crider, North Central High School, Indianapolis.

11:00-12:00 Noon Visits to Instructional Facilities and Laboratories of Evansville College.

12:00 Noon Luncheon, Cafeteria, Union Building.

1:15 P. M. General Assembly, Great Hall, Union Building, Craig Johnson, presiding.

Greetings, Dr. Nicholas Brown, Dean of Evansville College.

Business Meeting, Election of Officers and Presentation of Awards.

1:30-2:45 P. M. Program of Papers, President, Craig Johnson, presiding.

The following papers were read by members of the Junior Academy:

1. Investigations With a Home Heart Monitor, Frank Steiner, JETS, Central Junior-Senior High School, South Bend.
2. The Culture of Albino Maize, Marcia Lawlis, MSE Academy, University High School, Bloomington.
3. Synthesis of Amino Acids and Peptide Linkages Under Primitive Earth Conditions, Robert R. Batton, III, A. J. Kent High School, Kentland.
4. The Attitudes of School Children Toward Fallout, Valerie Savage, MSC Academy, University High School, Bloomington.
5. Thyroid Gland Studies (illustrated), Mal Stephens, Science Club, New Albany High School, New Albany.
6. The Comparative Study of the Effect of Propylthiouracil and Thyroid Substances on Metamorphosis in the Bullfrog, Kathryn Crider, North Central High School, Indianapolis.
7. Scientific Detection of Oil Painting Forgeries, Amy Suer, Gross Academy of Science, University High School, Bloomington.
8. Data Retrieval by Use of Magnetic Tape, Dennis Henry, Up-N-Atom Science Club, Crawfordsville High School, Crawfordsville.
9. Drosophila Chromosome Studies (illustrated), Danny Ware, Science Club, New Albany High School, New Albany.
10. Biochemistry and Genetics of Certain Bacteria, Irene Cuffey, Gross Academy of Science, University High School, Bloomington.
11. Internal Parasites in Mice and Men, Vicki Schmidt, Sigma Mu, Franklin Central High School, Acton.
12. Embryonic Heart Development of the Chick, Richard Wettrick, North Vernon Junior-Senior High School, North Vernon.
13. The Effect of Lysozyme on Certain Bacteria, Reba Koch, Science Club, Washington High School, Indianapolis.
14. Primary Investigation of Thymectomization on Mus Norwegicus Albinus; with Proposed Secondary Investigation on the Effect of Thymectomization on Resistance to Bacterial Infestations, Greg Lumbra, Gross Academy of Science, University High School, Bloomington.
15. Producing and Testing Penicillin, Janet Holscher, Sigma Tau, St. Rose Academy, Vincennes.
16. Effect of Temperature on Enzyme Induction in Escherichia Coli, Steve Barclay, Sigma Mu, Franklin Central High School, Acton.

17. An Experiment in Tissue Culture, Susie Talbott, Gross Academy of Science, University High School, Bloomington.
18. The Mathematical Relationship of the Four-Bar Linkage (illustrated), Gordon Clark, Science Club, Washington High School, Indianapolis.
19. An Investigation of an Electrical Interaction of Amino Acids and Enzymes, William J. Francis, Future Scientists of America, Garfield High School, Terre Haute.
20. A Living Fuel Cell, Craig Johnson, Science Club, Washington High School, Indianapolis.
21. The Transfer of P^{32} Through a Food Chain, Jane Richardville, Sigma Tau, Saint Rose Academy, Vincennes.
22. The Construction and Use of the "Durrum Type Electrophoresis Cell" in the Study of Blood Protein, Tony Rice, Rex Mundi High School, Evansville.
23. Genetics of the Fantail Pigeon, Sherman Wolfe, Science Club, Washington High School, Indianapolis.
24. Amino Acid Composition of Ice Age and Modern Snail, Carl Bose, Science Club, Westlane Junior High School, Indianapolis.
25. The Position of Static Charges, Michael Wright, Science Club, Westlane Junior High School, Indianapolis.
26. Column and Paper Chromatography, Lynn Ann Knabel, Memorial Chapter, J.A.S., Reitz Memorial High School, Evansville.
27. The Production of Cancer in Chicks, Cecilia Grannan, Memorial Chapter J.A.S., Reitz Memorial High School, Evansville.

Minutes of Indiana Junior Academy of Science

The thirtieth annual meeting of the Indiana Junior Academy of Science was held Saturday, October 20, 1962 in the Engineering Science Building and in Great Hall of the Union Building of Evansville College, Evansville, Indiana.

Seven exhibits of science projects by high school students were displayed in Room 203, Engineering Science Building. The exhibits included the following: "The Effect of Lysozymes on Bacteria"; "Thyroid Gland Studies"; "A Living Fuel Cell"; "Gas Chromatography"; "Cancer in Chicks"; "Internal Parasites in Mice and Men"; and "The Comparative Study of Propylthiouracil and Thyroid Hormones on Metamorphosis in the Bullfrog."

Conferences in science and mathematics were held at 10:00 a.m. by members of the faculty of Evansville College. The science areas represented were: Chemistry; Botany; Geography and Geology; Medicine and Related Fields; Physics; and Zoology. Mathematics, Engineering and Psychology completed the list of conferences. Visits to the instructional and laboratory facilities were made between 11:00 a.m. and 12:00 Noon. Members of the Junior Academy greatly appreciated the cooperation of the science faculty and student assistants who conducted the tours.

The afternoon session was held in Great Hall of the Union Building. The meeting began at 1:15 p.m. with remarks by the president, Craig

D. Johnson, who introduced Dr. Nicholas Brown, Dean of Evansville College.

Dean Brown welcomed the Indiana Junior Academy of Science members and their sponsors and extended the greetings of the faculty. He addressed the group briefly and emphasized that all should enroll in the social sciences and humanities as well as science. He stressed the fact that science has the power of good and evil and that it is man's responsibility to think in terms of social implications of the sciences. He said that "what to do and get is knowledge; what to be and become is know-why." It is education versus training; the difference is one of responsibility.

Mr. Edward Hudson, Kroger Grocery Company, Evansville, was called upon to present the annual Kroger Awards. The first place award of $50 and a plaque was presented to Tecumseh Junior High School, Lafayette. Mr. David Cole accepted the award for the school. Two runner-up awards of $25 and a plaque were presented to Alquina High School, Connersville, and Lawrence Central High School, Indianapolis. Mr. Walter Gronning, Science Teacher, accepted the award for Alquina, and Lawrence Central received the award in absentia. Kroger awards are presented annually to the three top-ranking high schools for outstanding school science programs judged from self-evaluating questionnaires sent to all high schools in Indiana.

The first item of business was the election of officers. Each club had received a ballot on which the nominees and their qualifications were listed. The club is entitled to one vote for each of the officers. The ballots were marked and returned to the Council or delivered by a representative of the club at the business meeting. The results of the election of officers for 1963 were as follows: President, Kathryn Crider, North Central High School, Indianapolis; Vice-President, John Gaiser, University School, Bloomington; and Vicki Schmidt, Franklin Central High School, Acton, Secretary.

The president then introduced the members of the Council, Mr. Robert Weber who was not present, Sister Suzanne, Mr. Donald Winslow, Mr. V. C. Cripe, and Miss Helen Reed. He announced that Mr. Erwin Steinkamp of New Albany was named the new Council member to replace Mr. Robert Weber, Fort Wayne, whose term expired this year.

The award for "best boy" in science was received by Frank Steiner of Central Junior-Senior High School, South Bend, and Craig Johnson of Washington High School, Indianapolis. Two girls shared the "best girl" award in science. They were Irene Cuffey, University High School, Bloomington, and Janet Holscher, Saint Rose Academy, Vincennes. A certificate of merit and a year's membership in the American Association for the Advancement of Science were presented to each of the above students. Dennis Henry, Crawfordsville High School, Crawfordsville, and Kathryn Crider, North Central High School, Indianapolis, received honorable mention and each was given a certificate of merit.

Dr. Walter A. Zygmunt, Mead-Johnson Laboratories, representing the American Society of Microbiologists, was introduced by the president. He announced that no project or paper warranted the monetary award, Craig Johnson and Reba Koch of Washington High School, Indianapolis. Certificates of honorable mention for papers were awarded to Irene Cuffey, University School, Bloomington; Janet Holscher, St. Rose Academy, Vincennes; Steve Barclay, Franklin Central, Acton, and Susie Talbott, University School, Bloomington.

The thirtieth annual meeting of the Indiana Junior Academy of Science was attended by 245 registered members, sponsors, and guests. A total of 23 schools were represented with 20 club sponsors present from 13 schools.

Twenty-six papers as listed on the program were read at the afternoon meeting. A brief review of each paper follows:

"Investigations With A Home Heart Monitor" was presented by Frank Steiner, Central Junior-Senior High School, South Bend. He found that by using a saline solution and bicarbonate of soda and an electrode set-up, he could detect pulse rates and heart murmurs. The electrodes were placed on the chest over the heart and on the ankle and the impulses in the body were recorded in seven and one-half seconds. Frank explained that the transmission of the impulses occurred in the same manner as messages over a telephone line. He suggested that a heart monitor could be useful in hospitals because it could reveal in a few seconds if the patient had had a heart attack or was a victim of rheumatic fever.

Marcia Lawlis of University High School, Bloomington, read her paper, "The Culture of Albino Maize." In her experiment she used three methods of study. One series of albino corn plants were fed a 0.3 molar sucrose solution through the leaf tip, roots, and stems. The plant which was fed through the leaf tip died in one week. A green one which she used lived from Jan. 27 to May 15. Two albino plants and two green plants were fed through the roots. One set was fed tap water, a second one was fed sucrose. After three days, the albino plant died, and the green plant in the sucrose solution was wilted. The stem feeding method involved two albino plants. One received sucrose, the second one tap water. The albino plants were kept alive as long as possible, but the plants did not form tassels. She concluded that the albino plants could be kept alive by artificial feedings.

"The Synthesis of Amino Acids and Peptide Linkages Under Primitive Earth Conditions" was read by Robert R. Batton, III of A. J. Kent High School, Kentland. He used paper gas chromatography to identify the amino acids. He stated that the acids were all organic and that identification of the acids has been possible and that research would increase the efficiency of the identification.

In her paper, "The Attitudes of School Children Toward Fallout," Valerie Savage of University High School, said that she had tested boys and girls in the fifth, sixth, and seventh grades. She found that the students had no psychological barriers to the questions asked. In answering some of the questions, seventy percent of the children agreed that they should not eat snow because it may be radioactive. Three fifths of the children agreed that each new school should have a fallout shelter. They also agreed that family fallout shelters should admit other people, but that pets should be allowed instead of the other people.

"Thyroid Gland Studies" was the paper read by Mal Stephens, New Albany. He showed several interesting slides of his laboratory at home and told how important it was to do the bookwork and to have the equipment. He used white rats and thyroxine, a hormone containing iodine. His primary research involved the recording of the basal metabolism in the treated and control rats. He found that there is a direct relationship between the thyroid level and basal metabolism.

Kathryn Crider, North Central High School, Indianapolis, also did a study involving thyroid hormones. In her paper, "The Comparative Study of Propylthiouracil and Thyroid Hormones on the Metamorphosis of the Bullfrog," she explained that the hormones and propylthiouracil were introduced into the aquaria containing individual tadpoles. She found that metamorphosis was initiated in four days in the tadpole being treated with triiodothyronine, in ten days in the tadpole treated with thyroxine, and none occurred in the one being treated with propylthiouracil. The control tadpole began its metamorphosis in four weeks. She concluded that thyroxine is not as effective as triiodo-thyronine in inducing a precocious metamorphosis, and that propylthiouracil inhibits the activity of the thyroid gland, thus retarding metamorphosis.

An interesting paper, "Scientific Detection of Oil Painting Forgeries," was read by Amy Suer, University High School, Bloomington. She said that there was no outlined procedure to follow in determining if a painting was a forgery. She indicated that there were several ways to detect a forgery, one was by smell, another was an examination of the brush strokes, the intensity of the color and the tones. She also said that X-ray and ultraviolet light could be used to identify forgeries in the paintings. Frequently the age of the paper can give the clue to a forgery.

Dennis Henry of Crawfordsville High School, Crawfordsville, reported on his research on the data retrieval unit which he built. In his paper, "Data Retrieval by Use of Magnetic Tape," he explained the apparatus which he had built. He explained that the deck in his apparatus was converted to solenoid operation so that it could be connected directly to the retrieval circuits. He used one solenoid each to control the following directions: forward, reverse (rewind), play/record (run), and stop. He could control the movements either manually or by the control deck, or electrically by lever switches on the front panel. Dennis felt that his deck gave a good performance and is probably the only one he could have converted to solenoid operation.

Danny Ware, New Albany High School, New Albany, used illustrations to explain his paper, "*Drosophila* Chromosome Studies." Danny said that one of the difficulties encountered was in the preparation of slides for comparison with known chromosome maps of *Drosophila*. He was able to develop a technique for slide preparation, and because of the reproduction rate in his test organism, he had chromosome material available at all times. The second step of his project involved the study of mutations and gene loci, and finally, he studied the loci of chromosomes which had crossed over. He concluded that it is possible to map chromosomes by comparison to a map of known locations.

Irene Cuffey of University High School, Bloomington, reported her research in a paper, "Biochemistry and Genetics of Certain Bacteria." Irene used over a thousand tests for her project. She used bacteria and bacteriophage for her research. She found that if bacteria were immune to bacteriophage, it was a result of a mutation. When the phage organisms are introduced into a medium containing bacteria, they will lyse the bacteria causing them to produce more phage particles. The second phase of her research involved antibiotic testing. This involved the streaking of one type of bacteria on agar and cross streaking with a second type. If one produced an antibiotic, the second was inhibited in its growth. She illustrated this with several pictures of the Petri dishes with the test organisms.

Vicki Schmidt of Franklin Central High School at Acton reported on "Internal Parasites in Mice and Men." Vicki used mice as her subjects because they are similar to man in relation to parasites. She had to weigh the mice and place them in separate cages. She used two methods for the determination of parasitism, the centrifuge and anal swab method. The second method is the simpler of the two. All one needs to do is examine the animal, place a piece of transparent tape at several places on the anus. The tape is removed and placed on a microscope slide with a drop of xylene. In order to locate the internal parasites, it is necessary to sacrifice the animal. Then the animal is dissected and the worms studied.

"Embryonic Heart Development of the Chick" was read by Richard Wettrick, North Vernon Junior-Senior High School, North Vernon. He reported that the heart of the chick embryo was a highly specialized blood vessel which beats without an external stimulus and that it developed systematically with blood vessels. He said that the embryonic heart does not function as the adult heart does, and that it was the first organ to develop in the organism. It is possible to see the heart with a microscope after twenty-four hours of development, and in 48 to 96 hours the atrium, ventricle, veins and arteries begin to develop.

Lysozyme is a naturally occurring substance found in tears, saliva, mucous secretions, and egg albumen and turnips according to Reba Koch of George Washington High School, Indianapolis. In her paper, "The Effect of Lysozymes on Bacteria," she reported that Fleming first observed the lytic effects of lysozyme. She used several quantities of dog tears, turnip juice, saliva, and egg albumen to determine if they had any affect on three types of bacteria. She found that they were more affective against gram positive than against gram negative bacteria. This could be explained by that fact that a second layer is found around the wall of gram negative organisms which is not present in gram positive ones, and it is easier for the lysozyme to penetrate the walls and lyse the bacteria.

In his study of the thymus gland and its removal, Greg Lumbra of University High School, Bloomington encountered two problems. One was the proximity of the thymus to vital organs, and the second was the open-heart surgery. In his paper, "Primary Investigation of Thymectomization on Mus Norwegicus Albinus: with Proposed Secondary

Investigation on the Effect of Thymectomization on Resistance to Bacterial Infestation," he reported that the thymus is most active when it weighs 45 to 50 grams. After the thymus was removed, he used a resuscitator to keep the lungs from collapsing. He said that the lymphocytes are produced by the thymus, and that the gland affects the rate of production of lymphocytes. The lymphocytes cause an immunilogical reaction on the body.

Janet Holscher, St. Rose Academy, Vincennes, in her paper, "Producing and Testing Penicillin," reported on her technique for obtaining *Penicillin* cultures. She obtained spores from an original culture of *Penicillium chrysogenum Wisconsin University Strain Q176* and transferred them to a penicillin production medium. She tested her work by using the fermentation broth of 1 ml. of penicillin broth per 9 ml. of water. She then saturated a filter paper disk and placed it on a Petri dish in which *Sarcina lutea* was growing. She then double checked her work by testing crystalline penicillin against the results of her broth culture. Clear zones of inhibition appeared around the disks if the penicillin inhibited the growth of *Sarcina lutea*. She found that the project took a lot of work, but the results rewarding.

"Effect of Temperature on Enzyme Induction in *Escherichia Coli*" was presented by Steve Barclay, Franklin Central High School, Acton. Steve reported that a living cell is induced to produce an enzyme when the proper "inducer" is present. Lactose served as an inducer for one phase of his work. Samples were taken every thirty minutes and were centrifuged. The fluid was poured off and a pellet was suspended in a phosphate buffer. The amount of protein present was measured and a qualitative analysis of the enzyme was made. He found, however, that the temperature had no effect on the enzyme production. He ran his control organisms at 43° Centigrade and his experimental Beta D organisms at 37° Centigrade.

An interest in tissue culture led Susie Talbott to report on "An Experiment in Tissue Culture." She reported that it was possible to keep cells alive outside natural environments. She used milk dilution and a special medium in with to grow her tissue cultures. The cells were titrated before being introduced into the medium, and then certain drugs were added. Nicotine was found to do considerable damage to the cells, and other drugs impeded the growth of the cells.

Using his linkage bars, Gordon Clark, George Washington High School, Indianapolis, explained the "Mathematical Relationship of the Four-Bar Linkage." He used three bars, two of equal length, and a third somewhat longer. A fourth bar was represented by the board to which the bars were affixed. He demonstrated how you could draw a figure eight and other figures by using these bars. Gordon explained that the principle of the linkage is important to industry and that the curves and lines drawn by the linkage can be determined mathematically by a formula which he had devised and proven to be accurate.

Craig Johnson, Washington High School, Indianapolis, explained his research with a "Living Fuel Cell." He explained that certain bacteria living in the sea are capable of taking the substances in the water and converting them to electrical energy. These are the sulfur-bacteria which act upon substances and release the hydrogen ions. These in turn are responsible for the energy production. He suggested that these bacteria might be used in our space program to generate electricity. Craig said that sawdust, garbage, and other waste material had been used in the research on these bacteria.

Jane Richardville of St. Rose Academy, Vincennes, explained "The Transfer of P^{32} Through a Food Chain." She said that the purpose of her experiment was to demonstrate the decrease of the element phosphorus in its passage from one organism to another. She used *Elodea* plants, snails and fish for her experiment. Ten microcuries of P^{32} were introduced into the beaker containing the *Elodea*. After seven days, the count was 1,216. Six snails were placed in the beakers with the *Elodea* and after one week, they were monitored and a count of 112 was recorded. The snails were crushed and fed to fish. When the fish were monitored, a count of seventeen was recorded for the skeleton. She prepared radioautographs and found a definite difference in the film so that she concluded that some of the P^{32} remains in the organism or is lost by waste or decay.

"The Construction and Use of the 'Durrum Type Electrophoresis Cell' in the Study of Blood Protein" was presented by Tony Rice of Rex Mundi High School, Evansville. Tony built the power unit for his research. In order to have a good migration of the blood serum, the cell is run at 2.5 milli-amps for sixteen hours. He encountered several difficulties with the test unit and corrosion of his wire strips on the paper wicks in the buffer solution. He found that the protein was not migrating far enough with his early work and after investigation found that platinum wire was used in cells. He rectified this by using a stainless steel rod. Then he ran the electrophoresis strips for sixteen hours at 2.5 milli-amps. The migration now moved too far and the protein would thin out and would be very light. He then cut down the time to fourteen hours. Next he placed each strip in methanol rinse for six minutes, after which they were dyed in "B 4" dye for thirty minutes. Then they were rinsed three times for six minutes and the strips were dried over night on a steel plate.

Sherman Wolf, Washington High School, Indianapolis, reported on his hobby, "The Genetics of the Fantail Pigeon." He said that the color, powder blue, is a desirable one in the pigeon. When he mated two powder blues, he had several results. One was barred, a second was spotted, and the third was plain powdered. By backcrossing, he was able to produce only the powdered. Now he is working with red and yellow fantails in order to develop a strain of pure red ones.

Carl Bose, Westlane Junior High School, Indianapolis, reported on "The Amino Acid Composition of Ice Age and Modern Snails." He had collected several specimens of snail shells which were of the Ice Age period. Then by crushing and centrifuging he was able to have a fluid substance in which the amino acids were found. By using paper chromatography, he was able to make a comparison of the amino acids in each type of snail. But since the snails have not changed to any great extent since their appearance on the earth, he found that there is little difference. The only difference in the snails at all is in their shape.

Michael Wright, Westlane Junior High School, Indianapolis, studied "The Position of Static Charges." Three phases were used for his investigation. The first involved an aluminum container and a static charge plate inside the container. Two electroscopes were used for the experiment. When the results were recorded, it was found that electroscope number 1 did not register an electrical charge, nor did the second one register. This indicated that the charge passed from the inside of the container to the outside, thus equalizing the static charges with the positive charges. The static charge was changed to a D.C. current in the second experiment. The results of this experiment were also negative. In the last phase, a glass container and a static charge were used. This time both electroscopes indicated an electrical charge. From his experiment, Michael concluded that: an electrical charge will pass to the outside of a container no matter whether it is a conductor nor not, a D.C. current will not necessarily pass to the outside, and the non-conductor slows down the passage of the charge to and from the inside.

"Column and Paper Chromatography" was reported on by Lynn Ann Knabel, Reitz Memorial High School, Evansville. She found that when she tested what seemed to be solid colors, they proved to be several. Lynn reported that colorless substances could be tested by the descending and elliptical methods, and that they too showed several colors to be present.

The final paper of the afternoon was presented by Cecilia Grannan of Reitz Memorial High School, Evansville. Her paper, "The Production of Cancer in Chicks," revealed that common carcinoma is caused by a virus. She injected the chicks twice with the virus in a 0.20 to 0.5 solution. When she autopsied her animals, she found that in addition to a lump on the breast, there were some on the gizzard. She said that reports of research indicate that there is a definite relationship between the virus and cancer.

The president, Craig Johnson, then thanked the Dean of Evansville College and the members of the faculty for making the facilities available to the Indiana Junior Academy of Science for their meeting.

He announced that Prof. Howard H. Michaud who had been a guiding light for the past seventeen years for the members of the Indiana Junior Academy was now the president of the Indiana Senior Academy of Science and Dr. Thomas Overmire of Ball State Teachers College would assume the duties of State Sponsor of the Indiana Junior Academy of Science. Craig introduced both Prof. Michaud and Dr. Overmire, thanking Prof. Michaud for his devotion to the Academy members and for his inspiration and guidance throughout the years he had served as State Sponsor.

Following this announcement, the meeting was adjourned at 4:30 p.m.

KATHRYN CRIDER, Secretary

INDIANA JUNIOR ACADEMY OF SCIENCE CLUBS

FALL OF 1962

Towns	*School and Club*	*Sponsor*
Acton	Franklin Central, Sigma Mu (1958)	Jerry Colglazier
Bloomington	H. S., National Scientific Honor Society (1931)	Merril L. Crisler
Bloomington	University Jr. H. S., MSE Club (1960)	Chas. Souers
Bloomington	University H. S., Jr. Academy (1938)	Don R. Winslow
Chesterton	H. S., Science (1954)	Robert McCord
Clarksville	Our Lady of Providence H. S., Phy-Chem (1956)	John Chilks
Clayton	H. S., Jr. Academy (1951)	Howard C. Leslie
Columbus	Jr. H. S., Academy of Science (1959)	Albert Sheets, Jr.
Columbus	Senior H. S., Science Club (1958)	L. N. Carmichael
Connersville	Alquina H. S., Science Club (1960)	Walter Gronning
Crawfordsville	H. S., Up-N-Atom (1950)	David Wells
Edinburg	H. S., The Alchemists (1954)	S. C. Harrell
Elkhart	H. S., Jr. Academy (1940)	Robert Mahan
Evansville	Reitz Memorial H. S., Phi Chi Mu (1958)	Sr. Francetta Sr. Peter
Fort Wayne	Central H. S., Biology (1940)	Iva Spangler
Fort Wayne	Central Catholic H. S., Albertus Magnus Science Club (1952)	Sr. M. Magdelen S.P. Sr. Jean Margaret S.P.
Fort Wayne	Elmhurst H. S., Phy-Chem (1935)	Ruth Wimmer
Fort Wayne	North Side H. S., Nature (1936)	
Fort Wayne	South Side H. S., Jr. Academy of Science (1956)	Robert Weber Don Weaver
Gary	Lew Wallace H. S., Biology (1935)	Lola Lemon
Gary	Lew Wallace H. S., Klub Kem (1941)	Mrs. Helen McKenzie
Gary	Tolleston H. S., Biology (1952)	John Reidel
Gary	Tolleston H. S., Future Scientists of America (1949)	Arthur Kline
Gary	Wirt H. S., Biology (1945)	Mrs. Frances Huddleston
Gas City	Mississinewa Joint H. S., Science (1936)	Roy McKee
Griffith	H. S., Science (1953)	George M. Bunce
Hamlet	H. S., Science (1954)	Lawrence Cushman
Highland	H. S., Science (1961)	
Hobart	H. S., Science (1952)	Lola Stewart

Towns	*School and Club*	*Sponsor*
Indianapolis	Fulton Jr. H. S., Science (1962)	Mrs. Bernadine Proctor
Indianapolis	Howe H. S., Science (1949)	Jerry Motley
Indianapolis	Ladywood School, Guerin Science (1957)	Sr. Pauline Marie Sr. Louise
Indianapolis	Manual H. S., Sat. Morning Science (1962)	Wayne E. Dunbar
Indianapolis	Saint Agnes Academy, Science (1959)	Sr. Amelia
Indianapolis	Shortridge H. S., Naturalists' Club (1947)	Robert A. Weaver
Indianapolis	Shortridge H. S., Science (1931)	Mrs. H. A. Parker
Indianapolis	Technical H. S., Nature (1932)	Chas. E. Russell
Indianapolis	Washington H. S., Science (1931)	Mrs. E. H. Crider
Indianapolis	Westlane Jr. H. S., Science (1959)	John Van Sickle
Jeffersonville	Clark & Floyd County Seminar (1959)	Harold E. Cook 1019 Springdale Dr. Jeffersonville, Ind.
LaPorte	H. S., Bi-Phi-Chem (1958)	Francis M. Gourley Byron Bernard
Lebanon	H. S., Jr. Explorers of Science (1953)	Helen Reed
Loogootee	St. John H. S., Science (1959)	Sr. Mary Ellen
Madison	Fr. Michael Shawe Memorial H. S., Shawe Science (1957)	T. A. Winkel
Mishawaka	H. S., Science (1936)	
New Albany	H. S., Science (1935)	Erwin Steinkamp
New Castle	H. S., Science (1947)	Betty Jo Montag
New Haven	H. S., Phi-Chi (1954)	Keith Hunnings
Oldenburg	Imm. Conception Academy, Heterogeneous Geniuses (1958)	Sr. M. Constance
Richmond	H. S., Science (1950)	Von Alexander
Rossville	H. S., Science (1954)	Martin Silverthorn
Sandborn	H. S., Up and Atom (1954)	Paul Carter
South Bend	Central H. S., JETS (1939)	V. C. Cripe
South Bend	John Adams H. S., Adams Walton (1953)	Ernest Litweiler
Terre Haute	Schulte H. S., Pius X Science Teens (1961)	Sr. Thomas Mary
Vincennes	St. Rose Academy, Sigma Tau (1959)	Sr. Suzanne
Washington	Washington Catholic H. S., Aquinas Science (1958)	Sr. Marian Francis

NECROLOGY

WILL E. EDINGTON, DePauw University

JOHN ORVILLE COTTINGHAM

Noblesville, Indiana	Indianapolis, Indiana
October 31, 1872	September 24, 1962

What to do following his retirement from the active business world was no problem to John O. Cottingham, who made an intensive study of mushrooms as an avocation. He was well acquainted with Charles C. Deam, of Bluffton, whose career as a botanist doubtless influenced him, for he began his mycological studies some forty years before his death in his ninetieth year on September 24, 1962, in Indianapolis.

He joined the Indiana Academy of Science in 1946 at the age of 74 and immediately became active in its work. As a result of his many years of study of mushrooms he presented in 1947 the first of a series of eight taxonomic reports on the "Higher Fungi of Marion County, Indiana," and concluded the series in 1956. In these reports, published in the Proceedings of the Academy, he listed 387 species of mushrooms found and identified in Marion County. At the request of the U.S. Department of Agriculture he filed his reports with its Botany Division. In two other papers, presented in 1951 and 1955, he discussed the edibility and quality of various species of mushrooms.

He was an ardent and enthusiastic botanist who carried on correspondence with professional mycologists in the Universities of Michigan and Minnesota and other institutions. At the Spring Meeting of the Academy in 1954, at Pokagon State Park, he read the proposal that led to the recognition of the Plant Taxonomy group, meeting with the Academy, as a Division of the Academy and he served as its first Chairman at the Fall Meeting that year at Purdue. He was elected a Fellow of the Academy in 1953.

John Orville Cottingham was born on October 31, 1872, in Noblesville, Indiana, where he received his public and high school education. His father, the Rev. H. A. Cottingham, was a Methodist minister who was a circuit rider before the Civil War and had charges in Broad Ripple, Castleton and other Indiana points. Rev. Cottingham had been a student in the mid-1850's at Indiana Asbury University, now DePauw, and it was natural that John should go to DePauw which he entered in 1892. However, he left the University before graduation to enter the business world. He became a prospector for oil in the Oklahoma oil fields around Tulsa, and later did sales work in Lawrenceville, Ill., Hartford City and Muncie, Indiana. Shortly before World War I he became a real estate broker in Indianapolis and followed that vocation until his retirement in 1940.

Mr. Cottingham was a lover of good literature and quoted freely from Shakespeare, Tennyson, Browning, Riley and other poets. He also spent much of his time on field trips pursuing his mushroom studies. At one time he owned a cottage on Tippecanoe Lake where he enjoyed fishing and boating.

He was a member of the North Methodist Church in Indianapolis, the Mystic Tie Masonic Lodge, Scottish Rite, and the Nature Study Club. As a student at DePauw he became a member of the Beta Theta Pi social fraternity. He maintained his interest in the University through the years and, in 1951, he gave his mycology collection, the result of many years of research, to the DePauw University Herbarium. His daughter was a 1927 graduate of the University.

John O. Cottingham maintained his interest in science to the end of his life. In 1959, at the age of 87, he attended the Dinner Meeting of the Academy of Science, held at Butler University, and thoroughly enjoyed the program. In his retired years he had made a permanent contribution to Indiana science that had secured for him national recognition as an authority on mushrooms.

CHARLES ALEXANDER DEPPE

Bay, Missouri	Franklin, Indiana
July 27, 1875	October 11, 1962

Until recently at least the history of most small colleges in America for any given period has been the history of some four or five instructors in the college whose professional lives were mostly spent in the service of the college and whose influence largely determined the success of the college. Strength of character, unselfish and unsung dedicated service and unusual ability to communicate with and influence youth through their teaching and personal lives have characterized these men. Such a man at Franklin College was Charles Alexander Deppe who spent 38 years of his life as Head of the Department of Biology.

He was born on July 27, 1875, in Bay, Missouri, a small village about 70 miles west of St. Louis. After completing his public school education at the age of eighteen he spent some time in Glenville, Nebraska, and St. Louis before entering the University of Missouri from which he received the A.B. degree in 1901. The next year he spent as a teacher of chemistry and German in Columbia Military Academy in Missouri. In 1902 he became a teacher in the Sedalia, Missouri, High School and six years later accepted a position as teacher of physics, chemistry and biology in LaGrange, Missouri, College, located in northeast Missouri on the Mississippi River. In his third and last year at LaGrange College he served as acting president and this college conferred the A.M. degree on him in 1910. He came to Franklin College in 1911 as Professor of Biology. He retired as Emeritus Professor in 1949 but continued teaching part time for three more years.

In most small colleges instructors have many duties and responsibilities besides teaching, and official titles frequently indicate only the major field of instruction of the title holder. Thus Professor Deppe regularly taught courses in geology at Franklin. Also he was a lover of music and possessed a good voice. As a young man he had taught himself to play the violin and cornet and he played in bands both in Missouri and Franklin, and he also played in and directed orchestras. In 1912 he organized and directed the first orchestra at Franklin College. As a student in the University of Missouri he sang in the University male quartette and the Glee Club, and at Franklin he directed church and college choirs in oratorios such as The Messiah. For a time he was an evangelistic singer during the summer months. He was a devout Baptist and at various times he served as Deacon, Sunday School teacher, Choir Director, orchestra director, and tenor in the choir of the First Baptist Church in Franklin.

He spent many of his summers in travel in Western United States, taking numerous pictures and collecting various specimens that he used in his teaching. He also did some graduate study in the University of Chicago. In his earlier years at Franklin he did some lecturing before Teachers' Associations in Johnson and Hamilton Counties, and he was visiting lecturer in biology in the summers of 1928 and 1929 at Indiana State Teachers College, in 1930 at Butler University, and in 1931 and 1932 at Ball State Teachers College. In 1920 Kalamazoo College conferred the honorary Sc.D. degree on him, and Franklin College did likewise at the time of his retirement in 1949.

In the years following his retirement he devoted much of his time to cataloguing and labelling the large number of geological specimens that he had collected through the years. He enjoyed making translations of German classics and in 1956, at the request of his children and friends, he wrote his autobiography which included much of historical interest about certain sections of Missouri.

Dr. Deppe was at one time a member of the Franklin Kiwanis Club. He was also a member of Chi Beta Phi honorary science fraternity. He joined the Indiana Academy of Science in 1911 and was made a Fellow in 1931. He served as Chairman of the Program Committee when the Academy held its Fall Meeting in Franklin in 1930. He was listed in American Men of Science.

Dr. Deppe will be remembered as a teacher and scholar who considered the study of science as a study of the way the Creator works and he taught accordingly. He enjoyed reasonably good health and was able to go daily to his office in the Franklin College Science Hall until five days before his death, in his 88th year, on October 11, 1962.

JESSE JAMES GALLOWAY

Cromwell, Indiana	Bloomington, Indiana
August 23, 1882	April 10, 1962

Indiana University gave its first earned Ph.D. degree in 1883 to Charles Henry Gilbert, a zoologist. During the next ten years thirteen more Ph.D. degrees were conferred, some earned, some honorary. Most of these were in zoology, for David Starr Jordan, and later John M. Coulter, were active at Indiana University. However, in 1885, an honorary Ph.D. was conferred on John Casper Branner. Branner had come to Indiana University that year as Professor of Geology. Indiana

University gave no Ph.D. degrees after 1893 until 1908 and none in Geology until 1913 when the Ph.D. was conferred on Jesse James Galloway. He was the first to receive the degree under the direction of Edgar Roscoe Cumings, who is still living at the time of this writing.

Jesse James Galloway was born on a farm near Cromwell, Indiana, on August 23, 1882. In 1900 he graduated from Cromwell High School and returned there twenty-five and fifty years later to deliver the Anniversary Commencement Addresses. After high school graduation he entered Vorhees Business College in Indianapolis and became adept in shorthand and touch typewriting, which then had just been invented.

In the summer of 1903 he gave a demonstration of blindfold typewriting at the Indiana State Fair that received considerable newspaper publicity which so impressed Judge G. L. Reinhard, Dean of the Indiana University School of Law, that he went to Indianapolis, tested Galloway, and brought him to Indiana University as his secretary, in September, 1903.

After familiarizing himself with the campus routine, Galloway enrolled in the College of Arts and Sciences in the spring of 1904, expecting to major in mathematics and earn his way by doing secretarial work and typing for students. However, in order to be free at certain hours to work in the Dean's office he enrolled in an 8 A.M. course in general geology. He became so fascinated with the subject, particularly paleontology, that he received the A.B. degree in 1909 in geology. The next year he spent as a teacher in Ligonier High School. He then returned to Indiana University as a Fellow in Geology, received the A.M. in 1911, and the Ph.D. in 1913, following which he spent three years as an instructor in geology.

During his student days he was a member of the Indiana University cross country team, but his main extra-curricular interest was in dramatics. He became a member of the Indiana Club, which met weekly, and through this experience in the Club's productions he became an interesting lecturer and teacher who was witty and given to vitalizing his class room work with current information from the movies, radio programs and newspapers.

In 1916 he went to Columbia University as curator of paleontology and a year later became an instructor in geology. He was promoted to Assistant Professor in 1921 and ten years later became Associate Professor of Geology. However, that same year, 1931, Indiana University offered him a professorship in Geology and Paleontology which he accepted. The rest of his life was spent in Bloomington except for a number of summers spent in field trips by mule pack-train in southwestern United States and Yucatan, Mexico, prospecting for major oil companies. Also following World War II he served in 1945 as Head of the Geology Department in the American University in Biarritz, France. He retired in 1953 as Emeritus Professor of Geology and Paleontology. Shortly before his retirement a group of his former students, prominent oil geologists, honored him at the Convention of Petroleum Geologists in Houston, Texas, with a luncheon and presented him an engraved watch.

Professor Galloway's paleontological research covered a half century of study of Ordovician Bryozoa and Foreminifera. All his published research was of high quality and characterized by clarity of illustration and explanation, taxonomic soundness and orderliness of his observations and deductions. His intensive study of minute fossils led in 1933 to the publication of his "A Manual on Foreminifera," that brought him international recognition as a paleontologist. Following his retirement he continued his research in the study of stromatoporoids and published several papers on these extinct reef forming coelenterates, before a heart condition prevented further such intensive work. Over the years he was the author of over thirty scientific papers published in the leading geologic magazines. His only publication in the Proceedings of the Indiana Academy of Science was a joint paper in 1911 with Dr. E. R. Cumings.

Dr. Galloway became a member of the American Association for the Advancement of Science in 1916 and was made a Fellow in 1921. He was President in 1927 of the Society of Paleontology and Minerals, and he was a Fellow of the Geological Society. He was also a member of the Association of Petroleum Geologists. In 1948 he was made an honorary member of the Societe Geologique de France and in 1957 he was elected an honorary member of the German Paleontological Society. He was also a member of Phi Beta Kappa and Sigma Xi. He joined the Indiana Academy of Science in 1910 and was made a Fellow in 1935.

Dr. Galloway was a man that one remembered. Not only was he an excellent teacher and lecturer but he was also extremely proficient in pool, chess and bridge. He coached the Indiana University chess team from 1931 to 1947. He served for many years as librarian of the Indiana University Men's Faculty Club and was affectionately called "The Kingfish" by members of the Club.

Dr. Galloway died suddenly following a heart attack at his home in Bloomington, Indiana, on April 10, 1962.

WALDO LEE MCATEE

Jalapa, Indiana — Chapel Hill, North Carolina
January 21, 1883 — January 7, 1962

Few men other than professional newspaper columnists or syndicate authors can be credited with one thousand or more published articles, and it is almost unbelievable that a professional scientist could be the author of 800 scientific papers mainly on birds, insects and plants, besides 200 popular articles. Such a scientist and author was Waldo Lee McAtee, sufficiently recognized by his fellow scientists as to be starred and listed with 340 other American zoologists so honored from 1903 to 1938 in American Men of Science. He was also the author of two books, "A Sketch of the Natural History of the District of Columbia," in 1918, and "Wildfowl Food Plants," in 1939. Many of his publications are referred to in modern books and guides on birds and wildlife.

He was born on January 21, 1883, in the small town of Jalapa, a few miles northwest of Marion, Indiana. In 1900, at the age of 17, he graduated from Marion High School. He entered Indiana University that Fall and received the A.B. degree in 1904. From his sophomore year until he received his degree he served as Curator of the Museum at

Indiana University and in his senior year he also served as an assistant biological expert in the U.S. Biological Survey. Following his graduation he immediately became an assistant biologist in the Bureau of Biological Survey of the U.S. Department of Agriculture. In 1906 Indiana University conferred the A.M. degree on him. He spent the rest of his professional life in the Federal service.

He was given charge of economic ornithology in 1916 and five years later he was put in charge of food habits research. In 1934 he was made a technical advisor in the office of the Chief of the service and six years later he was appointed a technical advisor in the U.S. Fish and Wildlife Service, where he remained until his retirement in 1947. During the years 1920 to 1942 he also served as acting Custodian of the Hemiptera Section of the U.S. National Museum, and from 1922 to 1930 he served on the Committee on Land Utilization of the U.S. Department of Agriculture. During all these years in the Federal service he lived in Washington, D.C., except for a period in the mid-40's when he lived in Chicago. Following his retirement he took up his residence in Chapel Hill, North Carolina, where he died on January 7, 1962, just two weeks before his 79th birth date anniversary.

In 1961 Indiana University recognized his many years of distinguished service as a biologist and ornithologist whose research work had played a major role in establishing national bird protection laws, and conferred the honorary Sc.D. degree on him. He had previously received other honors, being recipient of the Distinguished Service Award of the Department of Interior, and being made a Fellow Emeritus of the American Ornithologists' Union which he had served as Treasurer from 1920 to 1938. He was a member of Sigma Xi and was listed in Who's Who in America and American Men of Science.

He held membership in the American Association for the Advancement of Science, the American Society of Naturalists, Wilson Ornithology Club, and a number of sectional scientific clubs in Washington, D.C., New England and the Pacific Northwest. He was an honorary member of the Wildlife Society and edited its "Journal of Wildlife Management" from 1937 to 1942. He was also a corresponding member of the Royal Hungarian Ornithological Institute. His studies and travels led him to memberships in the American Folklore Society and the American Dialect Society. He was also a member of the Washington Free Thinkers of America.

Dr. McAtee joined the Indiana Academy of Science in 1928 and was made a Fellow in 1953. However, early in his career he appears to have been interested in the Academy for while he was a student in Indiana University he presented two papers before the Academy on birds found within five miles of the University campus, and a paper on "Mammals, reptiles and batrachians of Monroe County, Indiana." One paper on birds was published in the Proceedings for 1904. He was interested in the Academy and alert to the end of his life, for less than three months before his death he wrote to the author of this memorial suggesting that a biographical sketch on the life of Charles Henry Bollman, active in the early years of the Academy and who died in 1890, should be written and published in the Proceedings.

ROBERT JOHN SHEEHAN

Langdon, North Dakota
January 25, 1900

Notre Dame, Indiana
February 28, 1962

There is a certain satisfaction in knowing that a dedicated churchman is also an excellent scientist. During the past 400 years many bitter controversies have arisen because the interpretations of scientific findings based on experimental facts have clashed with the current orthodox beliefs. It has been difficult for the churchman unfamiliar with scientific methods to realize that the law of universal gravitation and the laws of motion are just manifestations of the way the Creator works and are just as immutable as any dogma. There can be no conflict between correct scientific interpretation of natural phenomena and truly spiritual facts. Today most thinking churchmen realize this and as a result some great church schools like Notre Dame are rapidly becoming research centers. Robert John Sheehan, C.S.C., at one time Head of the Department of Biology at Notre Dame was a dedicated churchman and an excellent scientist whose name may now be enrolled with the names of Julius A. Nieuwland and Francis J. Wenninger in Academy history.

Robert John Sheehan was born in Langdon, North Dakota, on January 25, 1900. In due time he entered the University of Notre Dame and received the B.S. degree in 1921. He then entered St. Louis, Missouri, University where the B.S. degree in medicine was conferred on him in 1923. He entered the Holy Cross novitiate in 1924 and a year later he returned to Notre Dame to enter Moreau Seminary where he earned the M.S. degree in 1927. He followed this with four years of study in Holy Cross College of Catholic University, in Washington, D.C., and was ordained a priest of the Roman Catholic Church in Sacred Heart Church at Notre Dame on June 24, 1931. That Fall he became an instructor in zoology at the Columbia Preparatory School, affiliated with Portland University in Portland, Oregon. Three years later he was made Assistant Professor of Zoology and Bacteriology in Portland University and was promoted to an associate professorship in 1938. During these years on the West Coast he continued his studies in science by extension work at the University of Oregon in 1937-38, summer work at the University of Washington in 1939, a summer at the Scripps Institute of Oceanography at LaJolla, California, in 1941, and a summer at Stanford University in 1945. Following all this fine preparation he was called to Notre Dame in 1945 as Associate Professor of Biology and Head of the Department. Ten years later, at his request, he was relieved of administrative duties and he devoted his full time to teaching and religious work.

Father Sheehan was a member of the American Association for the Advancement of Science, Society of American Bacteriologists, American Association of University Professors, American Institute of Biological Science, American Society of Zoologists, and Alpha Kappa Kappa professional medical fraternity. He joined the Indiana Academy of Science in 1945 but was not active in Academy work. He specialized in cytology, histology and medical ethics, and was the author of a mimeographed text, "Ethics for Doctors." He was listed in Who's Who in America and American Men of Science.

Father Sheehan was not only a good teacher, administrator and scientist, but also a devoted and beloved friend and counselor of his students and colleagues. His death occurred on February 28, 1962, at Notre Dame, following an aggravated form of emphysema.

JESSE ROBERTSON SINGLETON

Burlington Junction, Missouri — New York, New York
May 25, 1918 — July 5, 1962

A most promising career in science was brought to an end on July 5, 1962, with the death of Jesse Robertson Singleton, Associate Professor of Biology at Purdue University, at the age of forty-four. Stricken with cancer and following an operation in Lafayette, he entered Memorial Hospital in New York City where the third of three more operations proved fatal.

Jesse Robertson Singleton was born in Burlington Junction, Missouri, where he spent his boyhood and received his public school education. He entered Northwest Missouri State Teachers College at Maryville, Missouri, some ten miles from his home, where he earned both the A.B. and B.S. degrees in 1938. Intensely interested in biology he went to the University of Missouri where he did graduate work in cytology and received the M.A. degree in 1941.

Before continuing his graduate study he taught in the Kemper Military School, in Missouri, and Santa Barbara, California, College, and he also did some work for the New York Botanical Garden. In World War II he joined the Army in 1942 and saw service in Europe as an Army Warrant Officer before his discharge in 1945.

After the War he entered the California Institute of Technology and completed the work for a Ph.D. degree in genetics in 1948. This work was done under the direction of Dr. G. W. Beadle and in his thesis Dr. Singleton "succeeded in identifying the chromosomes and describing the chromosome cycle in the ascus of *Neurospora crassa*," a mold or fungus of the class ascomycete. His results were published in 1953 in the American Journal of Botany.

He returned to the University of Missouri in the Fall of 1948 as Assistant Professor of Botany. Six years later he went to Purdue as Assistant Professor of Biology and was promoted to Associate Professor in 1960.

At Purdue he taught courses in cytology, micro-technique, botany and general biology. An excellent and stimulating teacher with imagination he devised in 1959 a two-semester general biology course in which the student did actual experimental work in the laboratory that supplemented the lectures on the development of biological concepts and provided the student not only with a comprehension of the principles of life science but also with the thrill that accompanies research discoveries.

In 1961 he spent the summer at Stanford University where he became familiar with some new technical developments that might enable him to continue his cytogenetic research in the "mapping of the chromosome complement of *Neurospora crassa*." Shortly before his death the National Research Foundation made him a grant in support of this research.

Professor Singleton was a member of the Botanical Society of America, Association of Midwest College Biology Teachers, and Sigma Xi. He was listed in American Men of Science. He joined the Indiana Academy of Science in 1954 and presented one paper before the Botany Division.

Jesse R. Singleton held the highest respect and admiration of his colleagues not only as an exceptional teacher but as a researcher possessing unusual ability and insight in the field of cytogenetics. With his death Purdue University and the State of Indiana have suffered a distinct loss.

PARIS BUELL STOCKDALE

Frankfort, Indiana	Knoxville, Tennessee
August 30, 1896	March 18, 1962

Despite the importance of coal and limestone in the State's economy the study of geology in Indiana colleges and universities never reached graduate study importance until 1899 when Indiana University conferred the first M.A. degree in geology, although the University had regularly conferred earned Master's degrees since 1882. The first earned doctorate in geology at Indiana University was conferred in 1913 and since that time a number of prominent geologists have received the doctorate at Indiana University. Among these was Paris Buell Stockdale, Professor of Geology and Geography, and Head of the Department at the University of Tennessee for twenty years.

He was born in Frankfort, Indiana, on August 30, 1896. Following his graduation from Frankfort High School he entered Indiana University. He early became interested in geological studies and spent the summer of 1918 in the employ of the Roxana Petroleum Company. He received the A.B. degree from Indiana University in 1919 and began work on an advanced degree. However, he spent the year 1920-21 as an assistant instructor in geology at Williams College. The A.M. degree was conferred on him in 1921 by Indiana University and that Fall he went to Ohio State University as an instructor in geology. His Master's thesis, "Stylolites: their Nature and Origin," was published in 1922 in Indiana University Studies, Vol. 9, No. 55, pp. 1-97. In 1924 he took a leave of absence from Ohio State University and spent a year at the University of Chicago as a graduate student and Graduate Assistant in geology. During the summers from 1925 to 1929 he worked with the Indiana Geological Survey and the summer of 1930 was spent with the Ohio Geological Survey. He completed the requirements for the Ph.D. at Indiana University and received the degree in 1930. His doctoral thesis, "The Borden (Knobstone) Rocks of Southern Indiana," was published in 1931 in Publ. 98, Indiana Department of Conservation, Division of Geology. At Ohio State he was promoted to Assistant Professor of Geology in 1929 and four years later to Associate Professor.

In 1934 he was recipient of a grant-in-aid from the Penrose Fund of Geological Society of America that enabled hm to study the stratigraphy of the Mississippian rocks in Kentucky adjacent to those in Indiana which resulted in the publication in 1939 of "Lower Mississippian Rocks of the East Central Interior," as a special Paper of the Geological Society of America.

From 1929 to 1941 Dr. Stockdale taught the Ohio State University Field Course in a field camp in southeastern Tennessee near Dayton and became interested in the geology of the Tennessee River Valley. Consequently, in 1941 he left Ohio State University to become Professor of Geology and Head of the Department of Geology and Geography at the University of Tennessee. He also became a special consultant to the Tennessee Valley Authority for the next three years. He had served as a member of a sub-committee on Mississippi Stratigraphy, National Research Council, since 1933 and he continued this service until 1948. Following World War II, Ohio State University discontinued its Field Course in Tennessee but Dr. Stockdale enlarged and improved the facilities of the Camp and conducted it as a Departmental project and later turned its direction over to other members of the Department.

From 1945 to 1947 Dr. Stockdale was a member of the editorial board of the Geological Society of America. He spent the summer of 1948 as Professor of Geology at Columbia University. From 1948 to 1958 he was a consultant to the Atomic Energy Commission at Oak Ridge, Tennessee, and during that period, working with other members of his Department, he directed a contract study of the possibility of finding uranium ore in the Chattanooga shale that resulted in an extensive report that was published by the Commission in 1959. In 1961 he was stricken with an illness that forced his retirement from the University of Tennessee on August 31 of that year and resulted in his death in Knoxville on March 18, 1962.

Dr. Stockdale was an enthusiastic teacher, an efficient administrator and an excellent researcher. Prior to his coming to the University of Tennessee in 1941 the Department of Geology had granted a total of 12 Master's degrees, but during the twenty years that he was Head, the Department granted 115 Master's degrees and six Ph.D. degrees. Also the size of the Department staff had more than doubled and the quarterly enrollment had increased from 500 to 1,200 students. "He was recognized as a world authority on stylolites" about which he had published a number of papers and his stratigraphic studies on the Mississippian formations of Indiana, Kentucky and Tennessee are accepted as authoritative. Over the years he had made geological trips to mining centers in eastern and central Canada. In 1946 he took an extensive summer trip to the northwest Provinces of Canada that took him to the shore of the Arctic Ocean.

He was a Fellow of the American Association for the Advancement of Science, Geological Society of America, Paleontological Society of America, and a member of the Association of American Geographers, Geochemical Society and the Kentucky and Carolina Geological Societies. He was Vice-President of both the Ohio and Tennessee Academies of

Science and President of the Tennessee Academy of Science. As a student in Indiana University he was elected to Phi Beta Kappa and Sigma Xi. He was listed in Who's Who in America and American Men of Science.

He joined the Indiana Academy of Science in 1918 and was made a Fellow in 1929. He presented five papers before the Academy from 1928 to 1934, three of which were published in the Proceedings of the Academy.

Dr. Stockdale was civic minded. He was a member of the Knoxville Rotary Club, the Knoxville Technical Society and the Knoxville Science Club. An elder of the Erin Presbyterian Church, he served as clerk of its session for a number of years. He was an excellent violinist and in his student days he played first violin in the Indiana University Orchestra. While at Ohio State University he learned to fly an airplane which developed his interest in geography and meteorology. Later he took up archery as a hobby and be became sufficiently proficient and well known in archery competition so that he was President of the National Archery Association from 1941 to 1943. In his later years he enjoyed fishing.

Paris Buell Stockdale lived a full and effective life both as a citizen and a scientist who made valuable contributions to geological knowledge.

RICHARD LOCKWOOD WEBB

Farmer City, Illinois	Bloomington, Indiana
October 14, 1902	November 10, 1961

One thing that characterizes modern scientific research is the necessity for high specialization. This has led to great research centers, clinics, and other arrangements for coordinated efforts of numerous specialists permitting the continuous exchange of information and a more intelligent attack on any given more or less complicated problem. Nowhere is this more true than in the medical world. The numerous drives for funds to be used in research on cancer, polio, heart disease, multiple sclerosis, et cetera, are constant reminders. The research itself in the medical world is largely an intensive study of cells, glands, nerves, capillaries, brain centers, the chemistry of various bodily secretions and reactions, and psychical phenomena. In Indiana all are aware of the Indiana University Medical School and the great Medical Center in Indianapolis. One of the prominent medical scientists in the Medical School on the Indiana University campus was Richard Lockwood Webb.

Dr. Webb sought the source and mechanism of control of the circulation of the blood and lymph in the minute vessels of their circulation systems. His work had made him widely known among anatomists and physiologists in the United States. In his studies he used the wing of a bat which, because of its transparency, enabled him to observe the flow of the blood in the capillaries, and he and his colleague, Dr. Paul Nicoll, were able to make excellent moving pictures of the blood circulation. However, "his most absorbing interest was in the lymphatic vessels; here lay his greatest competence and major contribution." His broad knowledge and intensive research in his chosen field enabled him to publish a scholarly review of the field in the Annual Review of Physiology of 1952.

Richard Lockwood Webb was born in Farmer City, Illinois, on October 14, 1902. Following his graduation from Moore Township High School he entered the University of Illinois where he received the A.B. degree in 1924. During the next two years he was a graduate assistant in zoology at Illinois, but he received the M.S. degree in 1925. In 1926 he became an instructor in anatomy in the School of Medicine and during the next five years he completed the requirements for the Ph.D. degree in medicine which he received in 1931. Following the receipt of the Ph.D. he was promoted to Associate in Anatomy, and to Assistant Professor three years later. In 1939 he was made Associate Professor and became Professor of Anatomy in 1945. However, he spent the year 1945-46 as Visiting Professor of Anatomy in Washington University, St. Louis, and in 1946 accepted a professorship in Anatomy at Indiana University. Two years later he was made Head of the Department of Anatomy which position he held until 1958 when the departments of Anatomy and Physiology were combined. Several years before his death on November 10, 1961, he became afflicted with Parkinson's disease which prevented his continuing intensive research. However, he continued his study and teaching until a few months before his death when he submitted to a hazardous operation in the hope that his condition might be improved, but to no avail.

Dr. Webb was an effective teacher and a fair and efficient administrator who held the respect and admiration of both his students and his colleagues. "One of his principal teaching interests was in the anatomy of the nervous system, and it is ironic that it was a disease of the nervous system which resulted in his death."

He was a member of the American Association for the Advancement of Science, American Association of Anatomists, Phi Beta Pi medical fraternity, Gamma Alpha scientific fraternity, and Kappa Delta Rho social fraternity. He was a past president of the University of Illinois chapter of Sigma Xi. He became a member of the Indiana Academy of Science in 1947. He was listed in Who's Who in America. He was the author of a number of articles that appeared in professional and medical journals.

One can but regret the loss of this able scientist and teacher.

PRESIDENTIAL ADDRESS

The Nutritional Significance of Trace Elements

HARRY G. DAY, Indiana University

During the year that ends this evening a number of my colleagues have devoted much time and constructive attention to the work and needs of the Academy. It is not possible to give credits to all who deserve recognition, but the contributions of certain members have been so great and beneficial to the Academy I cannot refrain from naming a few.

We are especially indebted to L. A. Willig and Paul Klinge for their efforts in raising over $12,000 on short notice so that winners in our regional science fairs and their teachers might be sent to the National Science Fair. R. T. Everly and his Fellows Committee accomplished a great deal in the development of new standards and procedures for the selection and recognition of Fellows. Paul Weatherwax, R. T. Everly and W. A. Daily, serving as a special committee to study and make recommendations concerning the Constitution and By-laws, worked objectively and with great thoroughness. Others, including William Bloom, Kermit Carlson, Ralph Coleman, Sears Crowell, Richard Laubengayer, and Howard Michaud, merit our special thanks for their manifold hours of service and continuing support of the Academy.

In the choice of subject matter for my topic I have decided to survey briefly several aspects of research concerning trace inorganic elements that are important in various forms of life. I have decided to include only small amounts of my own research findings in order that the desired comprehensiveness of the subject might be presented.

Almost every element has been found to occur in many living systems ranging from microorganisms and plants to the highest animals and man. Nineteen are unquestionably indispensable for many forms of life including some of the highest animals. These include: hydrogen, carbon, nitrogen, oxygen, sodium, magnesium, phosphorus, sulfur, chlorine, potassium, calcium, manganese, iron, cobalt, copper, zinc, selenium, molybdenum and iodine. Three others are essential, each in at least one form of life. These are boron, silicon and vanadium. Some evidence suggests that essential biochemical roles may be played by arsenic, barium, strontium, nickel, titanium, bromine, chromium, rubidium, aluminum, and gallium. Thus, more than one-third of all the naturally-occurring elements may have important places in biology.

The term "trace elements" has been widely used for several decades but in some respects a more justifiable term is micronutrient elements. For elements which occur in large amounts or seem to be required in larger amounts by animals or plants the term macronutrient is applicable. However, because the latter terms have failed to gain common usage they will not be used in this discourse.

The distinction between trace element and major element is not simple. For example, zinc is always considered to be a trace element and iron is occasionally referred to as a major element. Although iron occurs in relatively high amounts in hemoglobin, and is therefore widely distributed, in some tissues and body fluids the concentration of zinc is somewhat higher.

Underwood (1), a significant investigator and writer in Western Australia, has pointed out that the determination of the biological essentiality of elements has been based on the following criteria:

> "(1) repeated demonstration of a significant growth response to dietary supplements of the element and this element alone; (2) development of the deficiency state on diets otherwise adequate and satisfactory, i.e., containing all other known dietary essentials in adequate amounts and proportions and free from toxic properties, and (3) correlation of the deficiency state with the occurrence of subnormal levels of the element in the blood or tissues of animals exhibiting the response."

The nutritional importance of some elements was established rather directly through the pattern outlined. Among these were zinc and magnesium. However, the initial recognition of the importance of some others has come about rather indirectly and in unexpected ways. For example, molybdenum was not suspected of being essential in anmials until by accident in studies of dietary factors affecting the activity of xanthine dehydrogenase in the intestines and liver of rats. Animals on certain diets had low amounts of xanthine dehydrogenase activity. Certain dietary supplements greatly enhanced the activity. The activity was finally shown to be attributable to the molybdenum which they happened to contain. The discovery of the involvement of molybdenum in the function of this enzyme was made almost simultaneously by two groups of investigators (2) working in different institutions.

Higgins, Richert and Westerfeld (2) made another unexpected discovery in the finding that tungsten is a molybdenum antagonist. Young chickens were fed a purified diet which contained tungsten, as sodium tungstate, at 1000 and 2000 times the estimated molybdenum content. Growth impairment and a marked decrease in xanthine dehydrogenase activity occurred. These effects were largely overcome by the addition of molybdenum to the diet. The antagonistic action was also demonstrated by the finding that the administration of sodium tungstate is quickly followed by a sharp increase in the excretion of molybdenum in the urine. The presence of tungsten in the diet does not affect the absorption of molybdenum from the alimentary tract.

Interrelationships of molybdenum with some other elements are also known. The well-known toxicity of molybdenum owing to the relatively high amounts in certain pastures can be alleviated by increasing the copper in the diet. Similarly copper toxicity through excessive amounts in the diet can be overcome by increasing the molybdenum intake.

Another example of the numerous cases of biological interrelationships between inorganic elements is provided by research on selenium and arsenic. In the attempts to find some means to reduce or prevent the toxicity of selenium when the diet contains several parts per million it was found by Moxon in 1938 that arsenic is effective. Arsenic in amounts of 5 ppm in the drinking water alleviates the injurious effects of selenium at 10 ppm in the diet of rats. The mechanism of this protection is not definitely known but Ganther and Baumann (3) showed that arsenic increases the elimination of selenium via the gastrointestinal tract. For a long time our primary interest in selenium was in its toxic effects. Finally, it was surprisingly found to be the essential component of a constituent of brewer's yeast which prevents some of the deficiency effects associated with vitamin E deficiency. Under some conditions there is not a large range between the amount required for metabolic needs and the level that results in toxic effects. This is characteristic of several elements.

My interest in the nutritional and biochemical significance of inorganic elements was stimulated when I began my graduate training in Professor E. V. McCollum's department at Johns Hopkins University more than 30 years ago. In the laboratory at that time investigations were being conducted concerning the nutritional significance of aluminum, fluorine, magnesium, manganese, and zinc. I contributed to the studies involving magnesium. After completing my graduate work I went to Yale University for postdoctoral training and then I returned to Johns Hopkins to serve on the faculty.

In the meantime the investigations by Professor McCollum and one of his students concerning zinc had failed to throw much light on the importance of this element, but work at the University of Wisconsin had substantially proved that it is a dietary essential for rats. In part from a sense of loyalty to Professor McCollum and because I was curious about the functions of zinc in the body, I began to study the nutritional significance of this element.

In the late thirties when this work was started it was very difficult to prepare experimental diets that were extremely deficient in the inorganic element to be investigated and which also would provide adequate sources of all other essential nutrients. This indeed was the problem concerning zinc. As early as 1934 Todd, Elvehjem and Hart at the University of Wisconsin had succeeded with a diet in which the concentration of zinc was demonstrably the limiting factor necessary for growth. Later, graduate students Stirn and Hove, with Professors Elvehjem and Hart, effected some improvements but still the diet contained approximately 1.6 ppm of zinc and it was not fully adequate in some other respects.

A particularly difficult problem was the preparation of a suitable source of protein or amino acids for the diet. Happily it occurred to me that the complexing agent used in some analytical methods for zinc, dithizone, might be effective if it should prove to be applicable to the separation of the element from a hydrolysate of a suitable protein. Fortunately, the company that is serving in part as our host at this meeting, the Mead Johnson Company, had recently developed a nutritionally adequate enzymatic hydrolysate of casein for medical uses. It was soon demonstrated that dithizone could be conveniently used to remove virtually all of the zinc from the hydrolysate as well as from several other components of the diet. This included a concentrate of liver that was necessary as a source of B complex vitamins which had not been identified at that time. Thus I was able to prepare a good diet which contained not more than 0.3 pmm of zinc.

The first paper (4) reporting our work was in 1940. A striking effect which quickly showed up was the decrease in growth rate. After a few weeks the deficient animals would lose weight and eventually die if not supplemented with small amounts of zinc. The same effect was noted later in mice.

Among the studies which we made were the determination of the activity of certain enzymes in the tissues. At the time carbonic anhydrase was the only enzyme which appeared to contain zinc. Its activity seemed to remain virtually unimpaired in the degrees of deficiency necessary to limit the growth rate. However, as shown by one of my students, Miss Blanche Skidmore, the catalase activity of liver and kidneys was markedly decreased but blood catalase was not affected (5). This effect was not changed by the addition of a zinc salt to the tissue preparations prior to the determination of catalase activity. Also, it should be noted that purified preparations of the enzyme do not contain zinc. Whether the element is associated with the enzyme under in vivo conditions apparently is not known.

Our observations concerning a decrease in the catalase activity of liver and kidneys but not in blood are comparable to those of Greenstein and his associates (6) who reported such changes in tumor-bearing mice and rates. A follow up concerning the significance of these findings should be made.

Because starvation and debilitating conditions in general do not affect the catalase activity of tissues we must assume that the decrease in activity in zinc deficiency is significant.

Owing to the chemical similarities between zinc and cadmium it was naturally considered that the latter might substitute for zinc. Our work (5) showed that in mice at least this will not occur. However, further attention needs to be given to this since Kagi and Vallee (7) have recently isolated from horse kidney a protein containing both cadmium and zinc. The purified protein contains 2.3-4.1 per cent cadmium and 0.41-0.76 per cent zinc. Of course the relatively large amounts of cadmium may constitute a storage form of the element somewhat comparable to iron in ferritin. It has been reported by another group that the harmful effect of even very small amounts of cadmium in producing sterility in male rats may be prevented by the simultaneous administration of zinc.

Through the help of Dr. Isaac Schour at the University of Illinois College of Dentistry histological examinations were made of the teeth from zinc-deficient mice and their controls. No changes in enamel or dentin were found in either the molars or incisors.

That the requirement for trace elements may be greatly influenced by other components of the diet is illustrated by the unexpected finding of Tucker and Salmon (8) in 1955 that zinc deficiency accounts for a spontaneous and endemic disease in hogs described as parakeratosis by Kernkamp and Ferrin in 1953. The disease is characterized by dermatitis, diarrhea, vomiting, anorexia, severe weight loss, and eventually death. It is induced with greatest facility when large amounts of calcium are fed. Even at levels of 30-35 ppm of zinc in the diet, a normal dietary calcium intake (0.48-0.82%) aggravates the symptoms of the disease and inhibits increase in body weight.

However, the relationship of zinc deficiency to the thickening of the skin and to some of the other features of porcine parakeratosis were foreshadowed by studies which Professor McCollum and I reported in 1940 and which Dr. Richard Follis, Professor McCollum and I (9) described later when we published a detailed study on the histological effects of zinc deficiency in the rat. We found hyperkeratinization, thickening of the epidermis, and intra- and intercellular edema of the skin and mucous membranes of the esophagus and mouth. Loss of hair occurred with virtually complete disappearance of the hair follicles, but the sebaceous glands remained intact.

In the esophagus there was a thickening of the epithelial cell layer together with the presence of an inner layer of incompletely keratinized cells. No indication of an increased proliferation of cells could be found as evidenced by mitotic figures. The changes can be interpreted as due either to a retardation in the normal keratinization of the epithelium which then is not removed or to an increased proliferation of cells.

Apparently the alteration of the esophagus is unique. As far as I know only one investigation since our work was reported has given any attention to the histological status of the esophagus. That was an extensive study by Nishimura (10) in 1953 concerning the importance of colostrum in the growth and development of very young mice. Nishimura transferred newborn mice to foster mothers 13 to 20 days post-parturient and compared their progress with controls who were left with their own mothers. He noted that the esophageal epithelium showed localized areas of superficial desquamation of epithelial cells, but he apparently did not make further studies of this structure.

Nishimura observed extensive alterations in the skin of the mice nursed by post-parturient foster mothers. The changes included thickening of the epidermis and hypoplasia of the hairs. The hair follicles were smaller than normal and their distribution was sparce and irregular. The sebaceous glands were normal in structure. Thus his observations confirmed the findings which my associates and I had reported twelve years earlier.

When Nishimura began his studies it was not suspected that suckling animals are especially dependent upon colostrum as a source of zinc. Various substances were administered to some of the animals to prevent the skin leasions and other disorders. Only salts of zinc or preparations of liver or yeast, known to contain considerable zinc were effective. Also, the foster mice had only three-fourths as much zinc in their bodies as the control animals.

These findings are now understandable because it has been shown (Spray and Widdowson, 1950) that in the early phases of normal growth in the rat and in the rabbit there is a considerable increment in the total amount of body zinc, much of which becomes concentrated in the epidermal structures. The concentration in sheep wool is great enough that in 8-10 lbs., which is normally produced by one animal in a year, there may be as much as 400-600 mg. of zinc. In general epidermal structures contain 70-120 μg. per gram of fat-free dry tissue.

It now seems probable that some of the disorders in the development of skin and its derived structures ought to be examined with regard to the nutritional requirements for zinc. There may be considerable differences between species in the needs for this element. The experimental mice and rats in my work seemed to get along well on supplements of zinc amounting to 4-6 ppm in the diet. However, swine indeed require greater concentrations in the diet. Possibly there are other unidentified factors in practical hog feeds besides calcium which account for the apparent high zinc requirements.

High concentrations of zinc are found in some other tissues, especially in the iridescent structures of the eyes of cats and related animals. The highest known concentration in any tissues is in the melanin-pigmented tissues of the eyes of some fishes. Other pigmented tissues tend to have high amounts of zinc. The dorsolateral prostate is also rich in this element, as shown in data given by Vallee (11) in a review on the physiological significance of zinc.

Much of the zinc is combined in proteins. At least 14 metal enzyme complexes are activated by zinc (11). The element activates or inhibits many enzyme systems, but in many cases the effects are not specific.

In general, the zinc metalloenzymes contain 1 or 2 atoms of zinc per molecule (11). The concentration of the element is approximately 0.18 per cent. However, in carbonic anhydrase the concentration may be 0.92-1.52 per cent. Recently in several different laboratories attention is being concentrated on metalloenzymes to study the topography of the active enzyme sites to determine the basis of enzyme specificity. For example, work on carboxypeptidase A by Vallee (12) has resulted in the identification of the -SH group of cysteine and of the α-amino group of the N-terminal asparagine residue as the metal binding sites of the apoenzyme. In work with different metals he has shown that each new metallocarboxypeptidase displays specific activities towards a series of substrates, characteristic of the particular metal which is incorporated. The effect on specificity is especially notable when Hg^{+2}, Cd^{+2}, and Pb^{+2} replace zinc. The mercury, cadmium and lead "carboxypeptidases" are actually only esterases. As Vallee (12) has rightfully pointed out, these principles offer unusual experimental opportunities which have already found application in the study of other metalloenzymes.

The fundamental aspects of inorganic element-enzyme balance are finding applications in various ways since, as my colleague, Professor Mahler (13), has stated,

> "There probably does not exist a single enzyme-catalyzed reaction in which either substrate, product, enzyme, or some other combination within this triad is not influenced in a very direct and highly specific manner by the precise nature of the inorganic ions which surround and modify it."

Another colleague, Professor Weinberg, has studied for more than a decade trace-metal control of specific biosynthetic processes. He has recently prepared a summary of findings (14) concerning specific distortions of metabolic processes by appropriate alteration of the balance of available trace and major inorganic elements. This summary lists 12 different elements which through changes in their concentration alters the metabolic patterns. In some instances the changes are manifested as disease, such as the parakeratosis in swine when the ratio of dietary calcium to zinc is excessive. In others it may be marked change in the production of a polypeptide antibiotic when the concentration of manganese in the nutrient medium is greatly altered. Or, as Hickey (1945) showed a number of years ago, the production of riboflavin by strains of *Clostridium* in a corn mash medium is greatly affected by the concentration of available iron even though the growth of the organisms is not appreciably affected.

Concerning imbalances and deficiencies that are known to involve human diseases certain elements are striking. These include iron, copper, iodine, and fluorine.

Anemias of different kinds occur. One of the commonest is based on combinations of impairment in iron utilization and the loss of iron through blood loss.

Wilson's disease has been recognized since the early thirties as a disturbance in copper metabolism which is accompanied by an excessive accumulation of the element in the liver. This discovery was made by my colleague Professor Haurowitz. It involves the presence of an excessive amount of a protein in the liver which has high affinity for copper.

Endemic iodine and fluorine deficiency (15) have been widely discussed in relation to goiter and dental caries.

Recent studies concerning post-alcoholic cirrhosis of the liver by Vallee and his associates (1959) and by others have shown that there is an increased excretion of urinary zinc and the concentration of this element in the blood serum is decreased. Also, the livers of some of the autopsied patients contained decreased amounts of zinc. The Harvard group has postulated that a conditioned zinc deficiency exists in post-alcoholic cirrhosis.

Various mechanisms may operate in determining the net effect of alterations in inorganic element balance. These include the participation of elements in specific structures of living systems such as iron in hemoglobin and zinc in carbonic anhydrase. An inorganic ion in appropriate concentration may suppress the synthesis of a particular enzyme or metabolite by activating the synthesis of other related substances. For example, in the studies of Nason, Kaplan and Colowick (16), it was shown that there is a marked increase in the production of diphosphopyridine nucleotidase (DPNase) by *Neurospora crassa* in a zinc-deficient medium. They postulated that in the absence of zinc, which was needed for the synthesis of other enzymes, much of the total protein synthesis was directed into a few kinds of "primitive enzymes" such as DPNase.

Much of the interest to date in trace inorganic elements, especially among enzymologists, has focussed on metals. The findings have been fundamental and they have led to various practical applications. Much more exploring and detailed investigations are necessary in this area. However, more attention needs to be devoted to the significance of several non-metals such as bromine, boron, and silicon.

Studies by Huff and his associates (1956) have indicated that bromine is necessary in the nutrition of chickens. Some earlier work by other investigators showed that if rats require it the need is exceedingly small.

Silicon apparently has not been studied with great care concerning need for it by higher animals. However, like bromine, it occurs in relatively large amounts in many forms of life including the highest animals. It is generally accepted that the element is needed in the nutrition of higher plants. Mast and Pace (1937) concluded that it is necessary in the nutrition of *chilomonas paramecium.* Obviously rigorous exclusion of it from the diet and environment of experimental animals presents challenging problems.

It has been almost 40 years since boron was shown to be essential in the nutrition of higher plants. The shortage of it in many soils is so widespread that 41 states do not have enough in one or more areas to meet the needs of certain crops. The element occurs in all tissues, but scarcely anything is known about its effects in the body of animals and man except that in considerable amounts of one of its best known forms, boric acid, it is "toxic." A few attempts have been made to determine whether or not it is essential in the nutrition of animals but the question remains unanswered. Investigations along this line are being initiated in my laboratory.

The contents of this cursory review have certain implications. The general subject is vast and therefore complex. Concerning many of the specific research findings it is tempting to draw sweeping conclusions especially in the applications to human nutrition. But owing to the many variables that operate and which in too many cases are not very well understood, it is frequently prudent to suppress such inclinations and critically search for additional facts and interpretations. Nevertheless there is no doubt that several of the inorganic elements in the diet and environment tend to be ingested in sufficiently abnormal levels as to substantially affect our health and the health of our animals and crops.

We know enough about certain problems and questions regarding some elements to justify deliberate modifications of the diet or drinking water to attain desirable levels of intake. For example, from a health standpoint we are justified in adding fluorine to the drinking water in many communities. We are justified in making iodized salt readily available in our food markets. But there is no justification yet in the addition of zinc or certain other elements to the average diet on the basis that striking effects of zinc deficiency may be produced in animals or that post-alcoholic liver cirrhosis is accompanied by an increased loss of this element from the body.

The problem of deciding what practical applications, if any, should be made, and how they should be made, regarding particular basic research findings is as complex and technical as the research itself. I leave further interpretation of this conclusion to all who are concerned with the application of science and technology to human needs, and I believe that includes all the members of the Academy.

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ANTHROPOLOGY

Chairman: Downey D. Raibourn, Indiana University
Richard Johnson, Indiana Historical Society, Evansville, was
elected chairman for 1963

Incidence of Arthritis in a Prehistoric Middle Mississippian Indian Population

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Arthritis is one of the oldest and most widely prevalent infirmities of men and animals. Until recently, it has also been one of the most neglected diseases for many have considered it a part of the inevitable aging process.

One of the most aged arthritic specimens resides in the Museum of Natural History at the University of Kansas. This large swimming reptile, Platecarpus, lived 100,000,000 years ago and had multiple arthritis. The Ape man of two million years ago had chronic arthritis of the spine as did Java man 500,000 years ago.[2] The lower cervical and upper thoracic vertebrae of Neanderthal man (40,000 B. C.) show arthritic involvement. Egyptian mummies of 8,000 B. C. also show evidences of this difficulty.

Comroe[2] devotes a chapter to spas and said that the Roman baths were built to help alleviate arthritic suffering. In "Yellowstone's Bannock Indian Trails," Wayne Replogle refers to the use of nature's steam and mud baths by American Indians. They prepared a liniment and also a methyl salicylate from Wintergreen (Gaultheria humifusa).

Authorities differ on the nomenclature and number of divisions to be used in the classification of arthritis. Osteoarthritis was called hypertrophic arthritis by Goldthwaite because the ends of bones were frequently enlarged and new bone is produced near the joint. Some cases are referred to as chronic senescent arthritis. Comroe[2] suggests that the term degenerative joint disease will prevent confusion over terminology.

Usually, joint changes occur to some extent in all persons past their thirties or forties. They do not necessarily notice any symptoms. The first changes occur in the synovial membranes, the articular cartilage and the articular surfaces of bone. Hyaline cartilage tends to undergo degenerative atrophy, osteophytes may form and produce new bony tissue in the joints. If this hypertrophic change is extensive and occurs in combination with rarefaction of the adjacent cancellous and cortical bone such things as perforation of the acetabulum can occur. Or, weight and pressure changes can cause a bending of the neck of the femur and subsequent crippling.

Another bone change observed is lipping of vertebrae, femoral condyles, and/or head of the tibia in particular. Lipping, or "mushroom" extension, occurs at the edge of the body of a vertebra and may vary from a small projecting rim to a large ruffly collar extending outwards even to the extent of forming an articulation with the outgrowth on the vertebra above or below. Complete fusion or ankylosis occurs more readily if the anterior and posterior longitudinal ligaments are areas of osteophytic deposition.

Dislocations and fractures can result in or near areas of constant pressure and friction. The rarified bone may bend and the constant wear will produce a different appearance of the bone. This process is referred to as eburnation. The bone is worn away and appears white and polished and looks very dense and hard but microscopic sections will show the wastage.

Of course, working on skeletal material in situ, it is not always possible to see all of these manifestations. These changes also occur in lower animals, one author referred to a horse skeleton which showed vertebral fusion at the area of the anterior longitudinal ligament due to strain from carrying overloads. In the Royal College of Surgeons Museum there is an extinct giant sloth whose great weight caused fusion of the lumbar vertebrae.

Osteoarthritis may result from trauma, mechanical or toxic; from an infectious agent by way of the blood stream; or from attrition. Articular cartilage has a disadvantageous position biologically and it is difficult for it to nourish and repair itself. One of the latest theories mentioned is that protein deficiency may be a cause.

Rheumatoid arthritis and spondylitis deformans are other pathological types but are differentiated from osteoarthritis by a general absence of osteophytic lipping and a type of ankylosis which eventually produces complete spinal rigidity combined with a deformity produced by a kyphotic curvature.

In order to determine the incidence and degree of osteoarthritis in prehistoric series, the following scale was employed:

Stage I—is characterized by slight lipping at the superior and inferior margins of the bodies of the vertebrae, or other joints,

Stage II—exhibits a more pronounced degree of lipping,

Stage III—is characterized by extensive lipping often resembling a mushroom-like eversion,

Stage IV—exhibits bony spurs or bridges with an increased mushroom-like outgrowth,

Stage V—presents actual ankylosis or bony union between two or more vertebrae, or other bones.

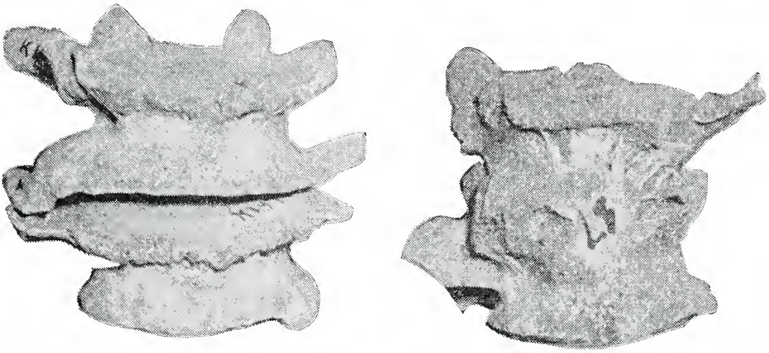
In all cases where the lumbar or cervical vertebrae were covered by portions of other skeletons, estimates were made, where possible, from other regions such as the scapula, and articular surfaces of the humerus or femur.

The skeletal material with which this paper concerns itself is located at Dickson Mound State Memorial near Lewistown, Illinois. Archaeologists have determined that these Indians lived in this area from 900-1500 A. D. and belonged to Spoon River Focus of the Middle Mississippi Culture. Over 200 burials, nearly all in extended position, have been excavated and a building has been erected over them to preserve them for educational purposes. The burial of the dead in wind-blown loess insured an excellent state of preservation.

The age determinations of this skeletal material were made by Dr. Georg Neumann,[1] and involved all available criteria, such as epiphyseal union, changes in the pubic bone, endocranial suture closure, etc.

The Spoon River Focus people were primitive farmers who grew corn, beans and squash. Charred traces of their food, animal bones and other refuse provide reliable evidence of their diet. Wild rice, acorns, maple sugar, fruit and nuts were also available in the area. Bones of fowl, fish and turtles were quite abundant. Of the larger mammals bear, bison, deer, wolves, foxes, raccoon, woodchuck, muskrat, and squirrel were hunted.

There were 47 cases of osteoarthritis among the 56 males aged 21 and over. After 47 years of age the incidence was 100% and the cases were more advanced in proportion to the number surviving. However, a case exhibiting Stage IV (Fig. 1A) was only 37, and the only case of vertebral ankylosis Stage V (Fig. 1B) was approximately 46 years old. The earliest example of moderate involvement had attained an age of 24; the oldest, an individual of 75, showed extensive changes Stage IV.



Figs. 1A and 1B. Lumbar vertebrae (K1476 and K1477) from the Crable Site in Fulton County, Illinois. These can be seen in the collection of paleopathology at Dickson Mounds State Memorial near Lewistown, Illinois.

Among the females, the population came to a total of 46, aged 21 or over. At age 45 or over, 100% of the women were arthritic. Of these, two were in Stage III and two in Stage IV. All the younger women only showed minor arthritic changes until the ages of 34 and 36 when Stage III lipping appeared. Of the total female population, 67% showed signs of degenerative joint disease.

The females had fewer advanced cases but there was a higher incidence of cases at an earlier age. This could have been caused by the strain and rigors of childbearing and birth in the days when the struggle for existence was so severe that a woman could expect little respite from heavy labor. Most of the work in the field, planting and harvesting, was done by the women in horticultural societies. The men usually cleared the areas and generally left the tilling of the fields to the women.

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[1] The author wishes to express her appreciation to Dr. Neumann of Indiana University for guidance and suggestions in carrying out this study, and Dr. Don F. Dickson for permission to study the material in his care.

Knaggs (1926, p. 158-9) suggests that infections in connection with birth injuries may explain the greater incidence of osteoarthritis in women of childbearing age than in men. Since Indian women had little obstetrical or gynecological care this might have been a valid reason.

Dietary deficiencies certainly could have aggravated a tendency to arthritis in the Indians and the constant exposure to cold and wet was a predisposing factor. General and local vitality was depressed and lack of medication and good care for injuries were debilitating circumstances.

In Hooton's study of the skeletal remains of Indians of Pecos Pueblo (5) a greater incidence of arthritis in younger females as compared with males parallels the findings for the Middle Mississippi sample. In the 503 adult or sub-adult Pecos skeletons, 20 or 3.98% showed some signs of arthritis in the long bones and short bones and joints. Of the 20, only two were young female adults. 57.14% of the female cases were middle-aged. Among the males, 15.38% were middle aged and 84.62% were old. Cases of spondylitis deformans occurred in 13.12% of this population sample. No sub-adults (18-21) had it and of the affected males 60.42% were "old" (over 50) and 66.67% of the females.

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Personality, Race, and Physique in College Women

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The present paper forms a part of an investigation into the physical and cultural basis of personality in college women. Our immediate concern is to explore the relationships between the racial and cultural background and body build. One aspect involves the preschool environment of the individual. Her cultural background and the economic level of her parents are reflected in her personality when she enters college.

In order to obtain this background information, a series of questions were asked pertaining to the subject and her parents. Of the subject was asked her age, class standing, place of birth, birth order, and number of siblings. The questions regarding both parents included age, place of birth, and educational level. The occupation of the father was also asked. Since the study involves both Negro and White students, the skin color of the subject is rated on a scale ranging from very light to very dark. This will give a rough indication of the degree of admixture of the Negro subjects.

In setting up the test we were working on the assumption that although the subjects would be selected from a State University, the educational level among the White parents will be higher than that of the Negro parents. One would, of course, expect considerable differences in the body build between the two groups of Negro and White students.

Since this is a pilot study involving only 36 Negro and 38 White students, the results can only reflect possible trends. Ultimately the study is planned to involve adequate statistical samples of each subgroup. The age range of the subjects is from 17 to 24 and is about the same for both groups. All are undergraduates and include freshmen through seniors.

In figure 1, the educational level of the parents of the subjects is given. It will be noted that twice as many of the Negro parents failed to complete high school as did the White parents. Several of the Negro parents did not go beyond junior high school. But beyond that level the difference is not as great, and it is very nearly the same for those who have a college degree or further study.

In our series among the Negro parents the mother tends to have more education than the father while in the White group the father far outranks the mother. When some of the Negro students were asked about this trend, they said that it was quite usual for the mother to have more education. This would support the psychologists' belief that the mother exerts greater influence in the education of the child than does the father. This would give new meaning to the socio-economic background of the subjects, their personality, and whether they enter college or not.

EDUCATION LEVEL

	Negro		White	
	Father	Mother	Father	Mother
Less than 12 years	8	8	4	4
High School degree	8	13	15	19
Less than 16 years	5	4	5	7
College degree or more	13	9	14	8
Education Unknown	2	2	0	0
Total	36	36	38	38

Figure 1

An examination of whether the economic level of the family rises with degree of White admixture was sought in the correlation of skin color with occupation as shown by figure 2. A correlation of the educational level in relation to occupation was not made of the Whites because of the obvious results. Skin color of the subjects was rated on the scale ranging from very light to very dark. Thus a Negro with a rating of 1 could pass as White. Of the subjects none of the Negros rated as very light and no White student rated as dark as number 2.

SKIN COLOR/OCCUPATION

	Negro				
Scale	1	2	3	4	5
Laborer		3	6	3	1
Office Worker			3		
Business		1	1		
Professional		5	9	1	1
Total	0	9	19	4	2

Figure 2

The correlation for skin color/occupation for Whites was very low. They were scattered at random through the various occupations with the same number of office workers as professional people and very few laborers. In the Negroes, however, there are nearly as many laborers as professional people with the majority of both groups being medium to light in skin color. There are very few who are in business for themselves or in some type of an office position. Keeping these occupations in mind, an examination of skin color in relation to birth place of the parents was made. Of the group classified as being of light skin, or number 2, there was an equal division of the parents being born in the North and in the South. In those individuals in the group of Medium skin color, or number 3, there was an overwhelming majority of both parents being born in the South, 82% of them. Those of dark skin color were all from the South with the exception of one set of parents, and in the 5th or very dark group, all were from the South.

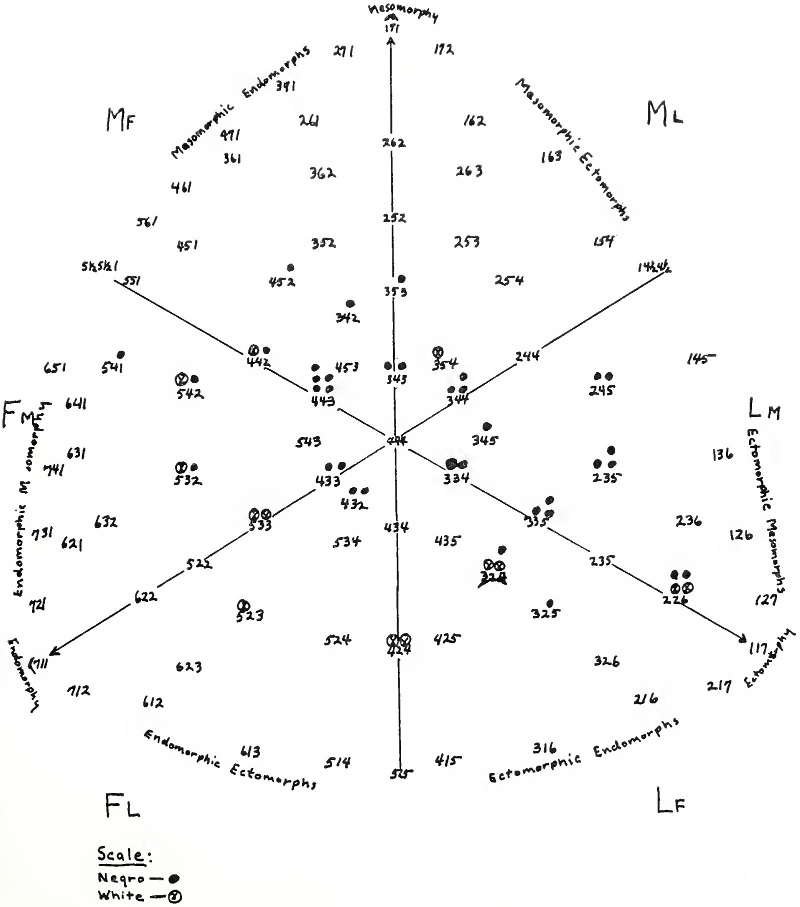

Figure 3

In figure 3 in which body build is correlated with racial grouping, I follow Parnell's method as it is more graphic than the methods used by Sheldon. This diagram shows that the Negro students tend to have a stronger ectomorphic and mesomorphic component than do the White students. Only a small sample of the White students are shown, but they are typical of the larger sample available. They tend to range from ecto-endomorphy through the lower part of the diagram to endo-mesomorphy. Nearly all of the light Negroes have a fairly strong mesomorphic component. The Negros of medium skin color show greater variability but still do not move into the strong endomorphy area. Most of them tend to be rather ectomorphic. Those of darkest skin color tend to be found right around the central portion of the chart.

Conclusions which may be drawn from these correlations can not be finalized until the major study is completed but inferences can be made in regard to the cultural background of the student and the socio-economic level of the parents. A greater number of the Negroes appear to be a part of recent migrations to the North. This is indicated by the fact that those of darker skin color were born in the southern part of the country. The socio-economic level of the Negro is influenced by his limited access to obtaining better positions, but while many of the fathers are laborers, there is greater emphasis being placed on college for their children. It might be pointed out that this is probably due to the influence of their better educated mother who is, as the psychologists have pointed out, more influencial in this area. All of this tends to be reflected in the personality of the college student, and on the whole the Negro student probably comes from a less stable environment than the White student.

Another fact inferred from this limited sample is the apparent presence of the high mesomorphic component in Negroes. To what degree this might influence the personality of the female Negro college student will have to await further investigation.

The Aymara and Uru Indians of the Peruvian Altiplano

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In the Altiplano area of Peru live some of the more primitive dwellers in a land of great contrasts. The sod houses in this part of the country are acclaimed as among the most primitive in the world. These windowless structures ward off freezing cold and heavy rains. Such is the land of the Aymara.

Out in Lake Titicaca are "islands," perhaps among the strangest in the world. They are formed of *totora*, a reed, and they seem to float. On these islands are the Uru Indians, some of whom speak Aymara and some of whom speak Quechua. Far from being "uncontaminated" by civilization, these island dwellers reflect nearly as much acculturation as do their neighbors on the mainland shores of the Lake.

The Uru Indians have been called the "Race of the Totora," for they depend in so many ways on this reed. Their man-made island is built of totora. Their boats are of totora. So are their houses and the lean-tos that protect their animals. Their animals eat the reed, and so do the people. This same vegetable matter is dried, woven, and used for pallet or sail, or for fuel for cooking.

Besides the tender heart of the totora plant, the Indians have fish and a kind of barley for their subsistence level food. Wild birds and bird eggs supplement the diet, and very occasionally mutton (fresh or dried) or a chicken will add a bit of culinary variety.

In addition to a pottery stove, which is just large enough to accommodate two pottery pots, the meager inventory of the family treasures will include usually a few dishes and jars, a *metate* and *mano*, and a few broken pottery vessels.

The vast extent of Lake Titicaca does mitigate the extreme cold of the Altiplano for the Urus. But one finds it difficult to admit that the reed houses could be classified as "adequate." The same must be said of the thin, worn, tattered and patched clothing of these Indians.

Surrounded, as the Urus are, by the Aymara Indians, and in more or less constant contact with them it is not surprising to find them becoming more acculturated to the ways of the Aymaras.

The Aymara Indians, who inhabit most of the territory surrounding Lake Titicaca have a bleak place to call "home." At an altitude of 12,000 feet the high plateau extends from horizon to horizon, scarcely broken. Basically an agrarian people, these Indians live constantly in fear of their own "Four Horsemen"—draught and flood, hail and frost. International, as well as national, agencies have frequently listed the Puno district around the Lake as a disaster area.

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1. This Peruvian work was made possible by a leave of absence from Loyola University and financed by a Fulbright Research Grant. The author is indebted to the (American) Maryknoll Fathers who provided him with operational bases and Indian informants in the Altiplano.

In one particular place, between Juliaca and Huancane a sodhouse type of dwelling has developed—possibly due to the fact that there are no trees—in which no wood is used. The sod blocks are cut from the bleak prairie and allowed to dry in the sun. The base of the house is about 15 feet square, and approximately five and one-half feet high. With a bit of mathematical ingenuity the Indians place a conical top on this square base. The sod blocks are laid turf-side down, and by omitting one or two of the blocks—in the top of the cone shaped roof—a tiny slit space serves for ventilation purposes. A bit of llama or sheep's hide can be stuffed into the small opening to keep out the bitter cold night air.

Some of these houses have no doors, but, more frequently, a few rough planks will be nailed together and placed before the opening to serve for a door. Occasionally one finds a touch of real elegance when a small entry way has been added to the door, and capped with a small corbelled arch. All of this architectural splendor will be made of the same sod blocks. A sod-house is assembled in a day, and will last about 20 years.

Of the domesticated animals that one finds with the Aymara Indians—and the list includes dogs, cats, chickens, sheep, pigs, alpaca, an occasional horse, etc.,—the most valuable seem to be the llama. His wool serves for clothing, his hide serves for mattress or blanket, the proximal end of the tibia is used for an awl in weaving. The meat is a rare treat. Most of the llama's life is spent in service as a pack animal. The slaughtering of a llama is reserved for a special occasion or for a sacrifice. The antiquity of the llama on the Altiplano scene is attested to in bas-relief carvings found on the *chulpas*, a pre-Incaic tower-tomb.

An item of ordinary trade in the market, the llama hide sells for about two dollars—and it costs almost that much to get one tanned well. But this is only one of the hundreds of items to be offered for sale or barter in an Aymara market. Other items include everything from corn (dried or cooked on the cob), to potatoes (fresh or frost dried *chuños*), to amulets (carved stone or dried llama foetus) for love or money; everything from fresh fish to pottery vessels and itinerant merchants' trinkets.

In a summary of this sort many details have to be omitted, and one can do little more than to indicate the rich potential awaiting further academic research. The linguist can find a few people who know the vanishing language of the Urus (which for all practical purposes has disappeared), as well as the currently spoken Aymara and Quechua. The archeologist has the rich Highland tradition including Tihuanacan ware to uncover and explain. The physical anthropologist has every sort of material from ancient artificially deformed crania to the Andean types of people to work with. And, of course, the ethnologist encounters innumerable problems with these Peruvian Primitives.

Role Interaction as a Factor in Kinship Classification

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In any kinship system, when two individuals occupy two different kinship positions but are called by the same term, it implies that they have something in common. Every since Morgan (6), it has been suspected that social organization was a basic factor as a determinant of kinship systems. Murdock (7) summarized and tested hypotheses of many researchers as they related to the determinants of kinship terminology. Kroeber (5), like others, emphasized social factors but he was more skeptical than most. Kroeber (4), stated in "Classificatory systems of relationship":

> Terms of relationship reflect psychology, not sociology. They are determined primarily by language and can be utilized for sociological inferences only with extreme caution.

Kroeber's skepticism was well founded. Of the eight principles he utilized, only two totally reflect sociology. Two others reflect sociology to a certain extent. The remaining four reflect language almost exclusively. Kroeber was looking at kinship systems frcm an overall perspective. Raibourn (10) pointed out that several researchers had indicated, or their data showed, that kinship systems normally begin to change in the cousin generation. One would expect, therefore, to find that cousin terms would reflect sociology to a much greater extent than would terms in other generations. Terms for other generations prior to their change towards an equilibrium would be more likely to reflect language simply because the terms used are older. Gifford (3) found this to be so among societies in California.

While Kroeber's skepticism was well justified, it should also be pointed out that even though terms of relationship do reflect psychology, they can also at the same time reflect sociology. Sociology and psychology are not mutually exclusive. The aim of this paper is to point out that social forces align individuals in such a way that they become involved in role interaction. Role interaction involves individual behavior. The institutionalization of individual behavior manifests itself in the kinship system. The position of individual behavior in the sequence has been implicitly, if not explicitly, stated by most writers on the subject. Others, however, have inferred or stated that the effect of social determinants upon kinship terminology was direct. It is the writer's contention that basic kinship systems stem only indirectly from such factors as residence, descent, exogamy, etc. Such factors are important because they align individuals in specific ways so that they can play specific roles with respect to each other. The specific roles which will be defined later are universal roles played in all societies. Such roles involve both kinship and nonkinship behavior. Each role manifests itself not only in human behavior but is also characteristic of mammals and many other animal groups, particularly avian species. The number of roles or role relationships involved are limited. There are only four:

(1) the authority-subordinate roles, (2) the sponsor-recipient roles, (3) the sibling and peer roles, and (4) the roles played by distant relatives and strangers. The specific objective of this paper is to demonstrate that five of the six basic kinship systems can be developed as a result of the playing of these roles. This does not deny the fact that certain aspects of kinship terminology result only from language and/or history.

The kinship diagram appended to this paper represents the six basic kinship systems extended through four generations. Each kinship system has been simplified as follows:

1. Each system is represented as in perfect balance. It should be remembered that total equilibrium is actually extremely rare. The systems of specific societies normally possess remnants of older systems. Most Indo-European languages, for example, possess survivals of early Indo-European. Terms such as paternal, maternal, in the English language, make it possible to classify certain relatives in accordance with the early Indo-European system.
2. The term for each relative has been translated to English. This makes the relationship between systems more comprehensible to English speakers. Utilizing English terms also makes it possible to point out more emphatically the effect of role interaction upon the development of kinship systems.

The collateral or bifurcate collateral system is defined as a system in which each relative is called by a distinct term which is not used for any other relative. The presence of the collateral system is difficult to account for. Of all the systems it seems to be the least influenced by social structural forces. Murdock (7) could find only one determinant for the system. He found that it tended to be associated with non-sororal polygyny. His coefficients and indices of reliability were not high because the collateral tendency was operating in opposition to exogamous unilineal kin groups which favor bifurcate merging terminology. This indicates that collateral terminology should be more frequent in societies with patrilocal residence which have not yet developed patrilineal exogamous kin groups; i.e. in an incipient Patri system.

Driver (1) pointed out another possibility. He correlated collateral terms with many traits of social structure and found that collateral terms correlated positively with several Patri and Bi traits. The highest positive coefficient was with a Bi division of labor in subsistence. Traits which correlated negatively were Matri traits and one Patri trait which was a Patri division of labor in subsistence. Since both Murdock and Driver found that division of labor in subsistence is the first social structural trait to change, Driver's correlations point out that collateral terminology is most likely to occur in a decadent Patri system, i.e., in an early Bi system which has just made the change from Patri organization. Raibourn (8) made a comparison of terms among some of the central California languages. Results were inconclusive as some favored Murdock's interpretation of the determinants of collateral terminology while others favored Driver's.

At present the determinants of collateral terminology remain unknown. Some of the writer's speculations concerning the determinants of collateral terminology are as follows:

1. Being non-classificatory, role interaction is not involved. Social structural influence would therefore be greatly reduced.
2. Language, not social structure, may be a basic determinant particularly if the system is totally in balance or nearly so. Murdock (7) seems to infer this also. In pointing out the rarity of his Sudanese type (collateral cross-cousin terms) he states that the distribution through Central Africa may have resulted from ". . . some obscure historical or linquistic cause. . . ."
3. If only certain parts of the system have collateral terminology, this may indicate not a former collateral system but could indicate simply that a change in system had occurred. A society moving to or away from the lineal system could very easily shift into temporary collateral terminology. Also the shift to collateral terminology could be made as a temporary transition to or away from either Patri or Matri asymmetrical terminology.
4. The rarity of collateral cross-cousin terminology and the quite common occurrence of collateral parent terms could stem from the different rates of speed at which terms in different generations change. With cousin terms changing first, with few social determinants for collateral terminology, the rarity of collateral cousin terms could be explained by the rapid change into other systems. Likewise the higher frequency of collateral parent terms could perhaps be explained by the slower rate of change for relatives of this generation.

The generational system recognizes one basic principle which is generation. Individuals within a single generation are classified together but are differentiated from individuals in other generations. Sex is usually differentiated but this is incidental to the system. The determinants of the generation system stem directly from social structure. Murdock (7) found them to be bilocal residence and the presence of bilateral kindreds. Both determinants place Ego in association with other relatives and involve strong role interaction. With bilocal residence, Ego will spend his childhood in close association with either father's or mother's parents, or at different times with both. He also finds himself closely associated with father's and/or mother's siblings and their children. With bilateral kindred present, the family is made up out of combinations of these relatives. Ego's cousins in the family unit will tend to play sibling roles with respect to him. From his point of view, they are identical to brothers and sisters and he tends to consider them as siblings. Likewise, his parents' siblings within the family unit tend to play parent roles and to be considered as such.

In Bi organization, parents tend to play both authority and sponsor roles. Authority stems from the division of labor in subsistence. Those who are the providers and protectors for the family tend to be the authority figures and the disciplinarians of Ego. In a Bi oriented society, division of labor in subsistence tends to be equalized between both sexes and both parents tend to play authority roles.

The sponsor role is played by the individual who acts as a sympathizer and helper of Ego. It is a counterbalance to authority. Since both parents tend to play authority roles in the Bi oriented society, both also tend to play sponsor roles.

The sibling role has certain similarities to the sponsor role in that sympathy or help may be given by a sibling or a peer. However, the relationship here is reciprocal. A demand is counteracted by an obligation. Sibling roles also frequently involve rivalry. Both rivalry and obligation are normally absent in the sponsor-recipient relationship.

The lineal system involves the recognition of two principles of classification. The generational principle is observed but added to it is the principle of lineation. Kroeber (4) defined this as a recognition of the difference between lineal and collateral relatives. Grandparents, parents, children, and grandchildren are relatives related to Ego in a direct line. These individuals are the lineal relatives. The remaining relatives such as uncles, aunts, cousins, nephews, nieces and siblings who are not related to Ego in a direct line are the collateral relatives. The lineal system lumps collateral relatives of the same generation together with the exception of siblings and cousins. Sex recognition is usually present though not always. English terminology is lineal and readily indicates the presence or absence of sex recognition. In English sex is ignored among cousins. For parent, sibling, and child terms, sex can be expressed or ignored. For uncle-aunt and nephew-niece terms sex must be expressed because there is no single collective term.

The determinants of lineal terminology as pointed out by Murdock (7) are neolocal residence and the independent nuclear family. These two determinants directly involve Ego in role situations which can explain the lineal classificatory system. The independent nuclear family and neolocal residence isolates Ego from close association with all relatives except parents, siblings, spouse, and children. Thus with the exception of siblings, the collateral relatives and the distant lineal relatives are outsiders. Only rarely can they play the roles of authority, sponsor, or sibling. Ego tends to view parents, siblings, and children as unique individuals who are different from all other relatives. He tends to consider collateral relatives, except siblings, as distant and to classify those of the same generation together. Relatives of the grandparent generation vary in their degree of distance. Grandparents normally are much closer to Ego than great uncles or great aunts. This latter would also serve as a factor for differentiating lineal from collateral relatives within this generation. While the degree of removal among distant relatives may vary, the role they tend to play when they have the opportunity is the role of sponsor. The authority role is generally absent, because the function of providing for the family rests exclusively within the nuclear family.

The lineal, like the generational system, develops within a Bi oriented society where both parents tend to be the providers of basic subsistence. Thus in both systems each parent tends to play both authority and sponsor roles with respect to their children.

A term for the symmetrical system has not appeared in the literature. The term symmetrical which is used here has both advantages and disadvantages. Its advantages are as follows:

1. Being a unilineal system, it contrasts with the other unilineal systems which have been termed asymmetrical.
2. Part of the system has been termed bifurcate merging. However, that type of terminology is also characteristic of the asymmetrical systems, since only parallel and lineal relatives are merged in the definition of bifurcate merging terminology.
3. The classifying of cross-cousins together which are differentiated from parallel cousins and siblings has been termed Iroquios terminology. This definition, since it refers only to cousin terms, is too specific to represent a complete system.

There seems to be only one disadvantage in the use of the term. It is not the only symmetrical system. The lineal and the generational systems are also symmetrical.

The symmetrical system observes three principles of classification.

1. The recognition of generation.
2. The differentiation of collateral relatives into cross and parallel.
3. The merging of lineal and parallel relatives.

Murdock tested the bifurcate merging principle in many ways but he did not test directly the classifying together of cross relatives within each generation. Yet with respect to cousin terms he did demonstrate conclusively that Iroquois cousin terminology was brought into existence by either Matri or Patri forces. Matri and Patri determinants would include factors such as unilineal types of kin groups, descent, exogamy, residence, marriage, and division of labor in subsistence. Each of these factors tend to align relatives in certain ways so that they can play specific roles with respect to each other. Each of these determinants also tend to produce asymmetrical terminology. Since the asymmetrical systems represent the mature form of unilineal organization, as pointed out by White (11), the symmetrical system is a transitional one. As a transitional system there are at least two forms of symmetrical cousin terminology as pointed out by Raibourn (9); one type is relatively stable, the second unstable and so arranged that the shift to asymmetrical terminology can readily be made. With respect to role interaction, there is no difference between the determinants of symmetrical and asymmetrical terminology. Time and the specific symmetrical arrangements seem to be the only significant factors involved in the differentiation of asymmetrical from symmetrical terminology.

As an illustration of role interaction, only the Patri system will be utilized. Matri organization would produce an identical symmetrical system even though the forces are reciprocal.

The base of the Patri system is a Patri division of labor. This means that males are the providers of basic subsistence. Father tends to play the authority role. With patrilocal residence, Ego finds himself associated with other authority figures such as father's brother, father's father and father's father's brother. Ego tends to identify each as a father. If sororal polygyny is present, mother's sister's husband may be father. With exogamous patrilineal kin groups, the chances are very good that mother's sister will live in Ego's community and will perhaps be married to an individual Ego tends to consider as a father.

When father plays the authority role, mother tends to be the sponsor. In the Patri family she is an outsider. The sponsor role is extended to father's brother's wife, and to mother's sister if she is in Ego's community because all are outsiders and each has much in common. The paternal parallel cousins always, and the maternal parallel cousins frequently, are in close association with Ego. Such closeness makes it possible to play sibling roles. When the above lineal and parallel relationships are institutionalized, the bifurcate merging part of the symmetrical system comes into existence so long as the generational principle is maintained.

The effect of role playing on the lumping of cross relatives is less direct. Cross relatives are normally distant relatives who rarely have an opportunity to play roles. With the exception of opposite sex siblings, they can never belong to Ego's kin group. As such they contrast sharply with parallel and lineal relatives. Unilineal organization tends to align cross relatives into role playing situations that tend to differentiate them and tend to produce asymmetrical terminology. Cross relatives would appear to have much more in common in an incipient unilineal system than in a mature form of unilineal organization.

Since cross relatives are normally distant relatives, historic and linguistic factors may also be of particular importance for the following reasons:

1. If the previous system was lineal, cross relatives would not have to be changed at all to shift to the symmetrical system. Only parallel and lineal would have to merge.
2. If the former system was asymmetrical, symmetrical terminology could develop as a means of moving out of the asymmetrical system. Raibourn (9) describes such a situation which occurred among the Wintu of central California.
3. If the former system was collateral or generational, the lumping of cross relatives would be based only on distant relatives. As such the lumping would seem to be less likely, but as mentioned previously, they would appear to have much more in common in an incipient than in a mature unilineal system.

The asymmetrical systems—the one Matri, the other Patri—ignore the generational principle of classification. Individuals so linked together in the kinship system have characteristics in common. In a Patri organized society, father, father's brother, father's father, and father's father's brother tend to play authority roles. If generation is ignored, they can be classed together as fathers. Likewise in a Matri society, mother, mother's sister, mother's mother and mother's mother's sister tend to be authority figures to Ego. Other asymmetrical alignments are more obscure. Murdock (7) tested and validated exogamous kin groups as a determinant. He further states (p. 168) that he suspects that amitate and avunculate relationships may be an important factor in the development of Matri asymmetrical terminology. The present writer tends to disagree and to view at least the avunculate relationship as destructive to the system for the following reasons:

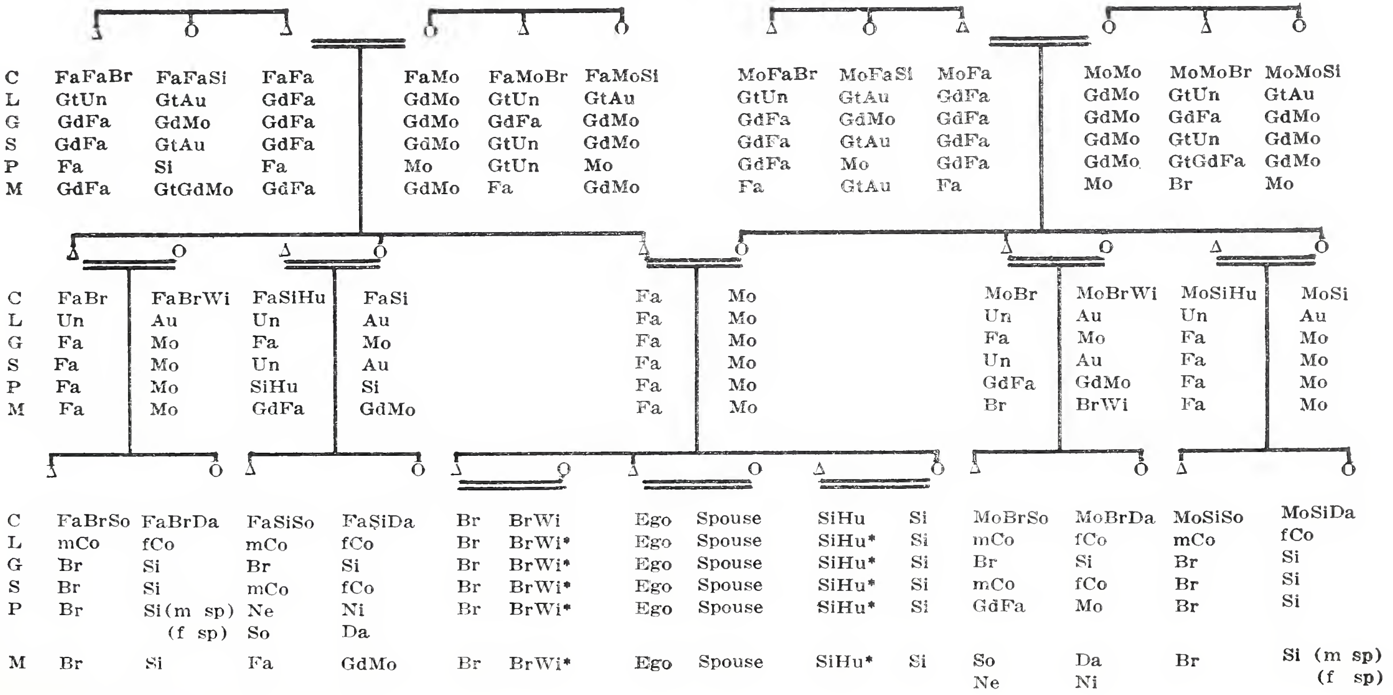
1. In the Matri system, mother's brother tends to be considered a brother. He, Ego, and Ego's brother have much in common. They belong to the same kin groups and all of them move out at marriage. The roles normally played would be sibling or sponsor roles.
2. The avunculate changes the relationship to one of authority for mother's brother. The Hopi as illustrated by Eggan (2) classify mother's mother's brother with brother but have a different term for mother's brother. This alignment seems to imply that formerly all three individuals were called by the term for brother. The distinct term for mother's brother would have tended to develop as a result of the avunculate. Mother's brother as the disciplinarian of Ego could hardly be considered a brother.
3. The association of the avunculate with asymmetrical terminology, which Murdock pointed out, could stem from a historical situation. The asymmetrical system is a mature form of organization. As such it would be more likely to attempt to preserve itself under the influence of change than would an incipient system. The avunculate being a means of preserving Matri institutions which have come under the influence of basic Patri or Bi determinants would be more likely to be found associated with the mature asymmetrical system.

Specific sibling and sponsor role interactions which are factors in the Patri asymmetrical alignments are as follows:

1. Father's sister would have many of the characteristics of a sister. Both would have the same residence prior to marriage. Both would have to marry outside the kin group. If father's sister was approximately the same age as one of Ego's sisters, the similarity between them would be exceptionally strong. Likewise, father's sister's husband would tend to play the same role as sister's husband. Father's sister's children would tend to be called nephew or niece if Ego was male or son and daughter if Ego was female, providing the cross parallel distinction among siblings is observed.
2. Mother's brother's daughter would have the same characteristics as mother's sister and both would tend to have characteristics in common with mother. Mother's brother's daughter and mother's sister would frequently reside in Ego's residential community after marriage. Both might be married to father or or to a classificatory father. All three would belong to the same kin group and stem from the same residential community. From mother's brother's daughter's point of view, Ego's mother and mother's sisters appear to her as sisters. Ego's mother's brother is her father and Ego's mother and mother's sister are, to her,

CHART I. Classification of Grand (Parent-Uncle-Aunt), Parent-Uncle-Aunt, and Sibling-Cousin generations

Relatives as Classified in the Six Kinship Systems When
in Total Equilibrium and translated to English Terms

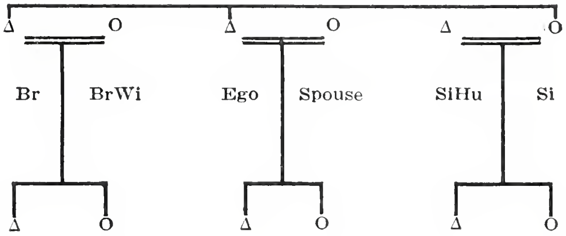


C	FaFaBr	FaFaSi	FaFa	FaMo	FaMoBr	FaMoSi	MoFaBr	MoFaSi	MoFa	MoMo	MoMoBr	MoMoSi
L	GtUn	GtAu	GdFa	GdMo	GtUn	GtAu	GtUn	GtAu	GdFa	GdMo	GtUn	GtAu
G	GdFa	GdMo	GdFa	GdMo	GdFa	GdMo	GdFa	GdMo	GdFa	GdMo	GdFa	GdMo
S	GdFa	GtAu	GdFa	GdMo	GtUn	GdMo	GdFa	GtAu	GdFa	GdMo	GtUn	GdMo
P	Fa	Si	Fa	Mo	GtUn	Mo	GdFa	Mo	GdFa	GdMo	GtGdFa	GdMo
M	GdFa	GtGdMo	GdFa	GdMo	Fa	GdMo	Fa	GtAu	Fa	Mo	Br	Mo

C	FaBr	FaBrWi	FaSiHu	FaSi	Fa	Mo	MoBr	MoBrWi	MoSiHu	MoSi
L	Un	Au	Un	Au	Fa	Mo	Un	Au	Un	Au
G	Fa	Mo	Fa	Mo	Fa	Mo	Fa	Mo	Fa	Mo
S	Fa	Mo	Un	Au	Fa	Mo	Un	Au	Fa	Mo
P	Fa	Mo	SiHu	Si	Fa	Mo	GdFa	GdMo	Fa	Mo
M	Fa	Mo	GdFa	GdMo	Fa	Mo	Br	BrWi	Fa	Mo

C	FaBrSo	FaBrDa	FaSiSo	FaSiDa	Br	BrWi	Ego	Spouse	SiHu	Si	MoBrSo	MoBrDa	MoSiSo	MoSiDa
L	mCo	fCo	mCo	fCo	Br	BrWi*	Ego	Spouse	SiHu*	Si	mCo	fCo	mCo	fCo
G	Br	Si	Br	Si	Br	BrWi*	Ego	Spouse	SiHu*	Si	Br	Si	Br	Si
S	Br	Si	mCo	fCo	Br	BrWi*	Ego	Spouse	SiHu*	Si	mCo	fCo	Br	Si
P	Br	Si(m sp) (f sp)	Ne So	Ni Da	Br	BrWi*	Ego	Spouse	SiHu*	Si	GdFa	Mo	Br	Si
M	Br	Si	Fa	GdMo	Br	BrWi*	Ego	Spouse	SiHu*	Si	So Ne	Da Ni	Br	Si (m sp) (f sp)

CHART II. Classification of Relatives continued for Child-Nephew-Niece generation



C			BrDa	BrSo	So	Da	SiSo	SiDa
L			Ni	Ne	So	Da	Ne	Ni
G			Da	So	So	Da	So	Da
S,P,M	m	sp	Da	So	So	Da	Ne	Ni
S,P,M	f	sp	Ni	Ne	So	Da	So	Da

Symbols used: Vertical line is descent line. Horizontal line represents siblings, double line stands for marriage. Fa=father, Mo=mother, Br=brother, Si=sister, So=son, Da=daughter, Hu=husband, and Wi=wife. Other relatives can be described by combination; example, MoBrDa=mother's brother's daughter. Gt=great, Gd=grand, Un=uncle, Au=aunt, Co=cousin, sp=speaker, m=male, f=female, Δ=male relatives, and O=female relative.

C —Collateral, descriptive, Sudanese
L —Lineal, Eskimo
G—Generational, Hawaiian
S —Symmetrical, Iroquois
P —Patri asymmetrical, Omaha
M—Matri asymmetrical, Crow

* In Bilateral Societies there seems to be a tendency to call BrWi, Si and SiHu, Br—but this implies Br-Si marriage. Some may use Br or Si in law or equivalent. In Unilateral societies there is a tendency to call same sex Br or Si opposite sex Hu or Wi. But same difficulty applies. Most societies simply have a non-classificatory, non-distinctive, sometimes descriptive term for these relatives.

father's sisters; and as pointed out above, father's sister is a sister. Thus both she and Ego would tend to view the three as identical.

3. The equating of mother's brother's son with mother's brother and mother's father involves less role interaction. All are Ego's distant relatives. From Ego's point of view, each of the three do have much in common. They form a direct line of lineal descendants in mother's Patri lineage. In their own lineage they form a direct line of Patri authority figures even though they do not play this role with respect to Ego.

The role interaction which results in the formation of the Matri asymmetrical system would be identical to the above with the exception that it would be reciprocal. For example, where father's sister tends to be called sister in the Patri system, she would tend to be called grandmother in the Matri. Each of the other relatives would be comparable for identical reasons.

The presentation above began with the grandparent generation, follows through the parent and then to the sibling generation. This presentation seems the most logical. Yet it implies that change normally begins in the more advanced generations. Murdock (7) seems to have considered this sequence the most likely for he states that when

> . . . the term for mother is extended to mother's sister, father's sister, father's brother's wife and mother's brother's wife, the daughters of such classificatory mothers tend to be called by the same term as sister, on the analogy of the relationship between own mother and her daughter.

This sequence, however, is now known to occur in, for the most part, a reverse order. As stated it violates the principle that kinship systems normally begin to change among cousins of the sibling generation. That the actual situation appears to be working in opposition to logic can perhaps be explained as follows:

1. Prior to actual change, role interaction would be operating on all generational levels.
2. The tendency to express such relationship first on advanced generational levels is perhaps present but expression may be blocked. The blocking could occur as a result of a learning factor. The tendency to express feelings of relationship instead of the correct linquistic terms would be most pronounced among the uninhibited. The least inhibited members of a society are its children. Children using kinship terms incorrectly would be more likely to be corrected in the presence of adults than in their play with other children. Since cousins are frequently of about the same age, misuse of cousin terms would be less likely to be corrected than misuse of terms in other generations where age differences are generally greater. The new or misused terms would be psychologically reinforced by repetitive use with less correction and could be carried along most easily into adulthood.

Among brother's children, sister's children and Ego's children, no distinction is made in the classification between symmetrical and the Patri or Matri asymmetrical systems. However, it is usually necessary to distinguish the sex of the speaker. All three unilineal systems distinguish between cross and parallel relatives. If Ego is male, brother is a parallel and sister a cross relative. If Ego is female, then brother is a cross and sister a parallel relative. Unilineal system of classification normally distinguishes the sex of the speaker in these generations though they may frequently ignore sex of the speaker in other parts of the system. Recognition or the lack of it seems to reflect language or historical factors, not social situations.

The analysis of kinship presented in this paper has been intentionally over-simplified. There are numerous factors which affect kinship classification that have not been included simply because they tend to promote a state in which parts of the system are out of balance. Most of these also involve role interaction. One example which was presented was the effect of the authority role played by mother's brother. The aim here has been to point out the effect of role interaction upon the basic rather than the idiosyncratic aspects of kinship.

Over-simplifiation has also occurred when the implication is made that both parents play both authority and sponsor roles in a Bi oriented society while father alone plays the authority role in a Patri or mother in a Matri society. Such roles played by individuals in any society are extremely variable. Such statements refer only to tendencies. In all societies there are individuals who vary in their ability to play their expected roles. This variability helps to account for the individual variability found in all societies. If all individuals in a society played their respective authority, sponsor, sibling, and distant relative roles identically, individual behavior within the society would be far more homogeneous.

In summary, it can be stated that role interaction involves authority, sponsor, peer, and distant relationships. Each are deeply rooted in mammalian behavior. In human societies this has led to the formulation of intricate kinship systems. The type of system depends upon the type of role interaction. The type of interaction depends ultimately upon the social situation.

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Is There an American Negro Race?

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The study recently made to answer this question consists primarily of a detailed morphological description and analysis of a sample of one hundred adult male Negro skulls of the T. Wingate Todd collection of Western Reserve University. The crania represent the earliest (1919-1921) acquisitions to the collection, mainly from the post-World War I period when the Cleveland Negro population consisted to a large extent of immigrants from the Deep South.

A comparison with West African Negro data clearly demonstrated the predominately West African origin of the slave population. On a morphological basis in which 66 observations were used, the sample was divided into a phenotypically unmixed group of 76 crania which proved to be typically Sudanid, and a mainly Sudanid-British White hybrid group of 24 crania which exhibited various degrees of hybridization.

During the analysis of the data it became apparent that a study such as this one must be made on a varietal rather than a subspecific (Sudanid-British White-Walcolid rather than a Negroid-Caucasoid-American Indian) level. Since subspecies are only to a somewhat lesser extent polytypical than species, it is difficult to find morphological traits typical of all Negroids, Caucasoids, or Mongoloids. On the other hand, when comparisons are made on a varietal level, the results become meaningful in a historical sense, and morphological, metrical, indicial, and genotypic seriological data confirm each other.

A comparison with morphological data on 116 adult male crania of Southern Indians of the Walcolid variety, the element that was involved in the mixture, demonstrated conclusively that the Amerind ancestry of the American Negro is negligible, and could be ruled out entirely for this sample.

Measures of variability, as indicated by the standard deviations of the means of measurements and indices of various series and sub-series and the curves of morphological observations, clearly demonstrate not only that the Total American Negro but also the Full American Negro series are more variable than the Walcolid American Indian series in nearly every respect.

The American Negro hybrid sample is too small to warrant drawing any valid conclusions, except that you do get a reassortment of morphological characteristics. Since the reassortment of such traits is an established fact and since the 300 years available for mixture constitutes too brief a time span, it would be scientifically unsound to accept the interpretation that a new specifically American Negro variety or race has emerged as a stabilized entity. The application of the morphological method to a larger statistical sample of American Negro crania promises to provide a useful tool for future research in the field of hybridization. To return to our initial query, the answer is definitely negative if we define a race as a stablized variety. The only way in which the Negro of the United States could be considered as constituting a race would be to designate it as a secondary or hybrid race or define the "race" as an inbreeding population irrespective of heterogeneity of origin.

The Peopling of the Philippines

CRISPINA C. SAPAULA, Indiana University

That the Philippines from part of the East Indies cannot be disputed. Admittedly, the mountains of Formosa can be seen in clear weather from the top of Iraya, a mountain on the island of Batan off the north coast of Luzon. But the connection with the islands to the south is stronger, and owing to bifurcation of the group, has more than one link. The sills that separate deep basins and break the surface to form the Talaud and Sangihe Islands join the Philippines to Celebes; and two submerged ridges, still broader and shallower, from which emerge the Sulu Islands and Palawan connect the group with Borneo. The lowering of the sea level by 25 fathoms would leave only two very narrow straits between the Philippines and the north-eastern end of Borneo and would more or less restore the outline that existed in the ice ages.

The forms of life also point to the inclusion of the Philippines in the East Indies. The flora and fauna have been found to include species that occur in Formosa, but they are only survivals and are restricted to the mountains. Northwards the isolation of the group seems to have occurred as early as the Oligocene, and it had definitely come about in the Pliocene, for Dipterocarps, which are not found in Formosa, appear in the limestone rocks of that period at Sagada in northern Luzon, and they are still common in the Philippines. The freshwater fish are related to those in Borneo, not those in Formosa.

The majority (62%) of the animal and vegetable species in the western East Indies also flourish in the Philippines, while only 26% are found in eastern Indonesia and Australia. This is proof that the connections with Celebes and the Moluccas were shorter in time than those with Borneo.

Distance from the equator and nearness to the mainland of Asia give the Philippines a monsoon climate in both western districts, and on the other hand a prevalence, especially in the north, of typhoons, which are unknown elsewhere in the East Indies.

The peculiarity of the Philippines also appears in its population. It is obviously similar to the rest of the East Indies in the superimposition and juxtaposition of ethnic groups and modes of life and in the succession and mingling of waves of cultural influence. Nearly all the streams of migration which have helped to form the existing population seem to have come mainly by way of Borneo. Most of the cultivated plants and domestic animals have been derived from the same region.

More than any other part of the East Indies the Philippines present an astonishing ethnical stratification. Anthropological research is far from complete; and in spite of the fine work of American scholars like H. Otley Beyer, the series of migrations and civilizing streams have not been established with complete certainty.

The historical era of the Philippines covered falls into three broad periods:

1. The *Prehistoric Philippines:* This era covers the period from the unrecorded beginnings to a point in time roughly coinciding with the beginnings of the Christian era.
2. The *Protohistoric Period:* This span of time reaches from the beginnings of the Christian era to the time of Magellan's landing in the Philippines.
3. The *Historic Period:* These four + centuries from Magellan's landing to the present day are amply documented by printed records and manuscript literature.

A backward bird's eye view of the Philippine prehistory shows six distinct cultural horizons clearly standing out.

First, there is the primitive human type similar to the Java Man of 250,000 years ago. Earliest stone implements and fossil remains have been found in Rizal, Bulacan, and Batangas provinces, recording a culture brought to the islands by slow overland migrations more than a quarter of a million years ago. This primitive man was accompanied by such huge mammals as the stegedon elephant and the rhinoceros. This early man wore little or no clothing, and lived only in caves or rock shelters provided by nature. He subsisted on such raw food as he was able to wrest from his surroundings by means of his primitive tools. It seems probable that this earliest man disappeared or became extinct about the time of the last glacial period, along with the large land mammals of his time. Apparently no living descendants of this primitive human survive in these islands today.

The second historical curtain raises much later, about 25,000 to 30,000 years ago, when the ancestors of the living pygmy people began to percolate slowly into the Philippines from the south over the various land bridges then in existence. The Negritos and other primitive Australoid-Sakai types of human being that still inhabit remote Philippine forest regions constitute a slowly disappearing remnant of this probably once extensive migration. The first wave of this migration of little people was probably the short, round-headed type classified as Proto-Malay. The evidence indicates they came into Luzon over a land bridge from Borneo, via Palawan and Mindoro some 12,000 to 15,000 years ago. Another group trekked over the Sulu land bridge into Mindanao about the same time. These people already had the blow-gun and bow and arrow for weapons, and probably practiced a crude kind of dry agriculture in forest clearings. They made and used many small stone implements—microliths. The descendants of the Australoid-Sakai type constitute about ½ per cent of the present population, while the Proto-Malay descendants from about 9½ per cent.

A very different group of people—the first sea-farers—the third group to come, came to the Philippines from the north some 5,000 to 6,000 years ago. These were the people of the Early New Stone Age, who had ground or polished stone axes, adzes, chisels, and other tools, round or oval in cross-section, which tell archeologically of a much advanced culture and craftsmanship. Their culture is now classified as

Early Neolithic or *Indonesian A*. These tall, slender immigrants left their blood and heritage to the Philippines and their descendants constitute about 12 per cent of the population today.

Fourth in the great waves of immigration came about 1500 B.C. and continued for approximately a millenium. These latter visitors were also sea-faring, coming from Indo-China and South China coast to Luzon and Formosa. Their distinguishing cultural contributions were houses with pyramidal roofs raised above the ground on four posts, advanced small wood-working tools made of very hard stone. They practiced extensive dry agriculture, and introduced upland rice, taro, new varieties of cultivated yams. Their clothing was beaten bark, often intricately embroidered with fine designs, printed in color with stone or wooden blocks. Many stone bark-cloth beaters and printers have been found among the remains of their ancient villages. This fourth migration is known as the *Indonesian B* or late Neolithic and descendants of these people number 18 per cent of the present population.

Fifth in the chain of incursions was probably a continuation of the fourth but was marked by a distinctly improved and advanced culture, featured by the use of metals. This fifth group began arriving between 800 and 500 B.C. and brought with them copper and bronze tools of their immediate predecessors. It seems probable that this advanced group introduced irrigated rice culture, and built the first rice terraces. They also introduced Central Asian methods of copper mining and smelting, and used the forge and bellows. This culture is usually known as the Copper-Bronze culture although it might well be called the Terrace Culture. The Copper-Bronze people were not numerically large, and their descendants probably do not compose more than 3 per cent of the present population.

The sixth and the last group of prehistoric migrations, occurring between 300 and 200 B.C. brought from the south a most numerous and advanced prehistoric people—the Iron Age group usually known as the Malays. They filtered in fleets of dug-out boats, up from the west coast of Borneo into Luzon via Palawan and Mindoro, and in another ocean pathways through the Celebes Strait to Mindanao and the Visayas. In addition to advanced irrigated agriculture, these migrants brought four new industries: (1) the smelting, forging and manufacture of tools, weapons, utensils and ornaments of iron and metals; (2) the manufacture of a great variety of turned and decorated pottery; (3) the art of weaving cloth on handlooms; and (4) the manufacture of beads, bracelets, and other ornaments of green and blue glass. These crafts seem to have originated in India, and to have spread from there to Indo-China and southern Malaysia, finally reaching the Philippines by way of Borneo and Celebes. This culture eventually was carried on north into Formosa, southern Japan, Korea and central Manchuria, where it finally disappears.

The existing population contains the physical types already mentioned above. These classes and types are defined only by average and betray every degree of mixture and transition. Within historical times the gradual modification of the population has continued through the introduction of Indian, European, Arab, American and Chinese elements.

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BACTERIOLOGY

Chairman: Gordon Mallett, Eli Lilly and Company

Richard D. Smith, Miles Ames Research Laboratory, Elkhart, was elected chairman for 1963

The inhibition of an RNA Bacteriophage by Streptomycin, using Host Bacteria Resistant to the Antibiotic.[1] Thomas D. Brock, Indiana University.—In most studies on the effect of antibiotics on virus growth, the host cells used have been sensitive to the inhibitory agent, so that a specific antiviral effect was not achieved. Growth of an RNA phage (MS2) of *Escherichia coli* is inhibited by 250 ug./ml. of streptomycin, even when the host cells used are resistant to the antibiotic. Streptomycin has no effect on free virus particles, or on adsorption of virus to cells. If antibiotic is added at the time of infection, no virus growth occurs, and there is a slow loss of infected centers. If antibiotic is not added until 5 minutes after infection (latent period of virus is about 15 minutes), it does not inhibit virus growth. Since streptomycin probably does not get into the interior of resistant bacteria, it is proposed that after adsorption of virus, there is a transient period during which free viral RNA is present at the periphery of the cell, where it can combine with streptomycin. If viral RNA has already passed into the cell before the antibiotic is added, it is now protected, and replication may proceed normally. Thus streptomycin may be a useful agent in analyzing the penetration of viral RNA into the cell. A variety of DNA phages of *E. coli* (Including a singlestranded DNA phage) are not affected by streptomycin, although a DNA phage of *Streptococcus faecium* is inhibited. In addition to its fundamental interest, this work raises the hope that specific antiviral agents for other viruses might be found.

The Concentrative Uptake of α-Methyl Glucoside by *Escherichia coli* D. P. Kessler and H. V. Rickenberg, Indiana University.—The concentrative uptake of α-MG by Escherichia coli strain ML was studied. The uptake system was stereospecific and of the carbohydrates tested only glucose inhibited α-MG uptake competitvely. The affinity of the uptake system was considerably higher for glucose than for α-MG suggesting that this particular transport system is in fact responsible for glucose transport under physiological conditions. Concentrative uptake of α-MG required energy. α-MG was not utilized by this strain of *E. coli* and the intracellular glycoside appeared to be in equilibrium with the α-MG of the medium. Unlabeled α-MG or glucose displaced the intracellular labeled α-MG.

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[1] Supported by grants from the U.S. Army Chemical Corps Biological Laboratories and the U.S. Public Health Service.

Rearing Germfree Rats on Chemically Defined, Antigen Low Diets[1]

JULIAN R. PLEASANTS and BERNARD S. WOSTMANN, University of Notre Dame

The potentialities of the germfree animal as a research tool of unusual precision have been outlined by Reyniers and Trexler (7) and Glimstedt (2). These potentialities are especially notable in areas of study such as immunology and nutrition, in which any living microbes could introduce new variables. For the immunologist, one such variable might be the non-specific stimulation of the reticulo-endothelial system by bacterial endotoxins. For the nutritionist, expected variables would include the destruction or synthesis of a nutrient by bacteria, and changes in absorption due to modification of the intestinal wall in the presence of bacteria.

But the mere absence of a living microbiota is no guarantee of freedom from bacterial influence. Germfree chickens have been found by Wagner (10) to have a low titer of antibodies against Micrococcus epidermidis after 200 days of age. This organism is one of the more predominant forms found in the dry diet ingredients before autoclaving. In addition to this, any ordinary laboratory-type diet, especially when steam-sterilized, contains a great variety of molecules of uncertain nutritional and antigenic properties.

There would therefore be a marked gain in precision if animals already germfree could be maintained on chemically defined diets, purified as far as practicable from bacterial products and foreign macromolecules. Such a regimen would not be fully effective, however, if started only at weaning. The permeability of the intestine during the suckling period, and the presence in milk of both antibodies and potential antigens, argue for the use of antigen-low diet from birth. In nutritional studies, the persistence of body stores of some nutrients, and the influence of early nutrition on later life, also argue for the use of a chemically defined diet from birth.

Although nutritionally adequate mixtures of pure chemicals had been elaborated earlier (8), the first such mixture that appeared readily adaptable both to sterilization for the germfree environment and to use as an infant formula was developed by Greenstein (3). This adaptability came from the fact that the diet was completely water-soluble, being designed for eventual use in parenterial nutrition. The diet had supported normal growth in mice (1), and growth, reproduction and lactation in rats through several generations (3). It remained for us, then to adapt the diet to the germfree animal as such, and in particular, to the requirements of the germfree mammal during its suckling period.

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[1] This research was supported specifically by the National Institutes of Health (Grant E-3449); also generally by the Office of Naval Research and the Army Surgeon General (Contract NONR-1623(04)); by the National Institutes of Health (Grant #A-556) and by the University of Notre Dame.

Apparatus and Method

Germfree Lobund strain rats at various stages during the suckling period, were transferred from their mothers' nest to plastic isolators of the Trexler (9) type and kept in a nest box similar to that of Gustafsson (5) except that heat came from a heating pad underneath the plastic

Weaned rats were housed in individual screen bottom cages within the plastic isolator. Bedding cannot be used because it is consumed greedily by the rats. The rats were offered soluble diet in Fisher animal drinking tubes. Distilled water was provided in overhead bottles with glass tubes. Towards weaning, the corn oil fed during the hand-feeding period was gradually eliminated, and Dextri-maltose gradually increased until it finally provided one half of the total solids of the diet.

Analyses of gastro-intestinal contents for osmolarity were carried out with a Mechrolab osmometer, model 301.
bottom of the isolator. The force-feeding technique of Pleasants (6) was followed, except that the natural latex nipple there described had to be replaced by a silicone nipple[2] which would not be attacked by the oily component of the diet. The 2 hour feeding schedule used for milk formula by Pleasants (6) was replaced by a 30 minute feeding interval in the final successful experiments.

The original Greenstein diet (3) with its later modifications (4) gradually underwent further changes at our hands in order to meet the higher needs of the suckling rat for cysteine, trytophan, zinc and sodium chloride. When weanling rats on this diet developed a hemorrhagic syndrome, the vitamin K_3 (menadione) of the diet was replaced by natural vitamin K_1. As the harmful effects of a high osmotic value in the diet became apparent, the 65% dextrose of the diet was greatly reduced and only partially replaced by Dextri-maltose (maltose and dextrins obtained by enzymic action of barley malt on corn flour). To replace the missing calories, corn oil was then fed separately from the diet. Table I gives the formula which was ultimately successful.

Results

Pilot studies with conventional baby rats force fed the high dextrose diet were rendered useless by a massive growth of mycotic forms in stomach and esophagus, sometimes entirely closing the esophagus. The relatively high pH of an infant rats' stomach (about 6.0) may explain why conventional infant rats fared less well than the conventional weanling rats used by Greenstein (3).

Initial attempts at hand feeding germfree rats, taken from their mothers within a few days after birth, were hampered by the development of severe intestinal distention. At this time the diet was high in dextrose. Most animals were lost by aspiration of diet into the lungs, either through misplacement of the feeding nipple or by regurgitation from an overdistended gut. Unlike milk formulas, the soluble diet forms no curd to stabilize it within the confines of the stomach.

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[2] The smaller of two nipples originally designed by the Walter Reed Army Institute of Research and obtainable commercially from the R. E. Darling Co., 4858 Cordell Avenue, Bethesda, Maryland.

TABLE I

Composition of Diet

Essential amino acids		Non-essential amino acids	
l-Lysine HCl	2.48 gm.	l-Aspartic acid	2.74 gm.
l-Histidine $HCl \cdot H_2O$	1.08 gm.	l-Proline	5.98 gm.
l-Tryptophane	0.80 gm.	Na-l-glutamate	12.04 gm.
l-Phenylalanine	1.80 gm.	Glycine	0.96 gm.
l-Isoleucine	1.00 gm.	l-Serine	3.10 gm.
l-Leucine	1.60 gm.	l-Alanine	1.50 gm.
l-Threonine	1.00 gm.	Ethyl-l-cysteinate•HCl	0.56 gm.
l-Methionine	1.20 gm.	Ethyl-l-tyrosinate•HCl	3.96 gm.
l-Valine	1.40 gm.	This combination is based on diet 26 of Greenstein et al. (3)	
l-Arginine•HCl	1.50 gm.		

Minerals			
MgO	0.15 gm.	Dextrose	30.00 gm.
Gluconolactone (for MgO)	1.30 gm.	Sucrose	8.00 gm.
CH_3COOK	2.12 gm.	B-mix 110	1.5 gm.
NaOH	0.90 gm.	Choline Cl	0.50 gm.
NaCl	0.76 gm.	Ethyl linoleate	0.80 gm.
Ca fructose $(PO_4)_2$	10.00 gm.	Tween-80	1.20 gm.
Salts 21	0.44 gm.	Ladek 50-E2	0.20 ml.
Na_2SeO_3 sol. 5.5 mg%.	0.4 ml.	Distilled H_2O	320.0 ml.

0.44 gm. Salts 21 contains: 280 mg. $Fe(NH_4)_2 \cdot (SO_4)_2 \cdot H_2O$; 102.6 mg. $ZnSO_4 \cdot H_2O$; 52 mg. $Mn(CH_3COO)_2 \cdot 4H_2O$; 6 mg. KI; 3 mg. $Cu(CH_3COO)_2 \cdot H_2O$; 1.8 mg. $Co(CH_3COO)_2 \cdot 4H_2O$; 1.2 mg. $(NH_4)_6Mo_7O_{24} \cdot 4H_2O$.

1.50 gm. B mix 110 contains: 1 mg. thiamine•HCl; 1.5 mg. riboflavin; 1.26 mg. pyridoxine•HCl; 7.5 mg. niacin; 50 mg. i-inositol; 10 mg. calcium pantotenate; 0.06 mg. biotin; 0.1 mg. folic acid; 20 mg. of 0.1% triturate of vitamin B_{12} in mannitol; 100 mg. ascorbic acid; 60 mg. p-aminobenzoic acid; 1.25 gm. dextrose carrier.

0.2 ml. Ladek 50-E2 contains: 2 mg. Vitamin A acetate; 1.4 microgm vitamin D_2 (calciferol); 10 mg. dl-alpha-tocopherol acetate; 0.44 mg. vitamin K_1; 0.19 ml. absolute ethanol carrier.

Notes: The order of addition described in Greenstein et al. (4) must be followed. The ethyl tyrosinate•HCl had to be dissolved very rapidly in its own weight of water, then added at once to the main solution.

The final diet was filtered through a GS Millipore filter (0.22 micron pore size) with glass fiber prefilter. The flask of diet was sealed off and passed into the plastic isolator through a lock sprayed with 2% peracetic acid. Within the isolator, this diet (28% solids w/v) was diluted to 14% solids for 3 day old rats. The level of solids was gradually increased to 19% solids for 20 day old rats.

Corn oil (0.05ml) was fed 4 times daily in place of a soluble diet feeding. In addition, the nipple tip was dipped in corn oil at each feeding of soluble diet for lubrication. This is estimated to have provided 0.10 ml. oil daily.

A 28% solution of Dextri-maltose, w/v, was mixed with the diet after weaning to raise gradually the proportion of carbohydrate without increasing total solids.

Since Greenstein (3) had found no intestinal distention in conventional weanling rats fed water-soluble diet, it appeared necessary at this time to determine if distention of the small intestine and cecum on this diet was peculiar to the hand-feeding period or was a reaction of the germfree rat as such. For this purpose germfree rats were offered the diet only after weaning. Although these suffered severe intestinal distention during a transition period of several weeks, and the majority died from volvulus of the cecum, those which survived became adjusted to the diet and grew at about ⅔ the normal rate of gain for periods up to 3 months. To see if the high osmolarity of the diet might be accentuating the general tendency of the germfree rodent to develop an enlarged cecum, most of the dextrose was replaced by the much higher molecular weight Dextri-maltose. This change substantially reduced the death rate in weanling rats during the transition period.

Efforts at hand-rearing were then resumed, with emphasis on reducing the osmolarity of the diet by diluting with water, by using less total carbohydrate and by making up the calories with separate feedings of corn oil. However, on the old two-hour feeding schedule it still remained difficult to provide enough calories and protein with this diluted diet while avoiding excessive stomach distention and risk of diet aspiration.

Analysis of gastro-intestinal contents[3] showed that even the diluted diet's osmolarity of 1.0 was considerably higher than the osmolarity of 0.35 to 0.4 found regularly in the small intestine of rats fed this same diet. Analysis of stomach contents at various intervals after feeding showed a rapid initial decrease of osmolarity to 0.7-0.8, followed by a slower rate of decrease thereafter. Apparently, water passed in less readily after an initial passage leading to severe distention of the stomach.

Until now the rats had routinely been fed at 2 hour intervals, a schedule carried over from much earlier experience with hand feeding of milk. A 30 minute interval was adopted and proved immediately successful. Feeding smaller amounts of the diet apparently did not impede the diluting and emptying of the stomach contents. The daily intake of food could now be doubled without creating severe gastro-intestinal distention. The incidence of diet aspiration dropped sharply. Out of 5 young, taken from their germfree mother at 3 days of age and fed every half hour on the diet in table I, one was sacrificed at 10 days of age. Its stomach contents, 30 minutes after feeding, showing an osmolarity close to that of the small intestine. The remaining four continued growing at the rate of 0.5 gm. per day during hand feeding, a rate of gain comparable to that of rats hand-fed on milk formula by Pleasants (6). They were weaned at 20 days of age and maintained to sacrifice at 59 days of age. Loss of fur and slow growth about the time of weaning indicated some general or specific inadequacy of the diet but resumption of fur growth at 6 weeks and gross normality of organs at sacrifice indicated no severe deficiency.

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[3] We are indebted to Dr. Dean Zimmermann for these and other analyses carried out in the course of diet development and also for valuable suggestions on diet ingredients.

Discussion

At this point, the most encouraging finding is the probability that no unknown nutritional factors are required by the infant rat. Although two poorly defined supplements, corn oil and Dextri-maltose, have been included in the diet in order to determine the influence of dietary osmolarity, it is planned to replace them as soon as practicable with chemically defined substitutes.

It is interesting that a method which quadruples forced entries into the esophagus should greatly reduce the risk of diet aspiration. This fact suggests that much of the earlier diet aspiration must have followed regurgitation from a stomach under extreme pressure. The osmolarity studies suggest that the stomach probably increased in volume for a time after each feeding as water was drawn in to dilute the hypertonic contents. Excessive distention of the stomach might also impair the stomach's ability to contract and force contents into the intestine. Frequent feeding of small amounts of food seems to have by-passed this particular problem by allowing for a certain amount of water to enter the stomach without its reaching a distended stage which interfered with emptying.

With the improved safety of the new schedule, we plan to go at once to the mechanically more difficult task of rearing rats on the diet from birth rather than from 3 days of age. As soon as practicable, the diet and technique will be tried on germfree newborn mice. Mice have proved very difficult to rear by hand (6) because of a high risk of diet aspiration. Virologists, however, prefer to see new strains of germfree mice started by hand feeding rather than by cross-suckling on other germfree strains which could be harboring latent viruses. If the present diet should improve hand rearing of mice, it would also improve the usefulness of the germfree mouse for virus and cancer research.

Current success with the new diet and technique thus encourages us to hope that this type of diet will permit more precise determination of the needs of suckling animals, hasten the procurement of new germfree species and strains, and improve the precision of the germfree animal as a research tool for the biological and medical sciences.

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Thiamine and Anti-Microbial Defenses[1]

P. LEONARD KNIGHT, University of Notre Dame

Introduction

Studies on thiamine metabolism have been carried out in our laboratory for several years; e.g., thiamine synthesis by bacteria of the digestive tract of the rat using radiosulfate as a precursor, the nature of the thiamine in the cecum, and thiamine-sparing action of penicillin. Recently, it has come to our attention, that thiamine may play an integral part in the antimicrobial defenses of the rat. This conclusion is based upon the results of studies of thiamine content of the liver and heart, of the regional blood flow to the liver and of the transketolase activity of the liver. In all experiments the comparison between germfree and conventional animals permitted an evaluation of the effect of the presence of a viable microbial flora.

Both germfree and conventional rats, age 21 days to 3 months, were used in these studies. Earlier work in our laboratory had shown that the heart of the germfree rat was 15-25% smaller by weight than the heart of its conventional counterpart (2). This fact in turn indicated that there might be a difference in circulation between the two groups. Cardiac output and regional blood flow were therefore determined as follows: The former was measured via the indirect Fick principle, using Sapirstein's adaptation (4) of the indicator method of Hamilton et al. (3). $Rb^{86}Cl$ was used as the test substance. Blood collections from cannulated carotids were made at the rate of 55/30 secs., each amounting to 0.03 ml. Blood flow to organs was determined after the method of Sapirstein again using $Rb^{86}Cl$ as the test substance. Animals were sacrificed 30 secs. after administration of the isotope. This isotope maintains a stable level in all organs (except the brain) between 10 and 60 secs. post injection and thus the fractional uptake of the indicator by various organs is equal to their blood flow fraction of the cardiac output.

All animals were sacrificed by decapitation. Livers and hearts were removed and analyzed immediately or frozen for later use. Thiamine was determined by a modification of the thiochrome method as outlined by Wostmann and Knight (5). Analysis of transketolase activity was made after the method of Brin (1).

Results and Discussion

As has been mentioned previously, the heart of the adult germfree rat is 15-25% smaller by weight than the heart of its conventional counterpart when the animals are on a complete thiamine diet (2), yet

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[1] This research was supported specifically by the Nutrition Foundation, Inc. (Grant no. 257); also generally by the Office of Naval Research and the Army Surgeon General (Contract NONR-1623), by National Institutes of Health (Grant AM 00566-10) and by the University of Notre Dame.

the amount of thiamine dihydrochloride/gram tissue (Table 1) is approximately the same in both groups.

TABLE 1

Thiamine in Hearts and Livers and Regional Blood Flow to Livers of Adult Germfree and Conventional Rats. S.D.M. Values Given.

	Thiamine 2HCl µgm/gm Heart	Thiamine 2HCl µgm/gm Liver	Regional Flow ml/min./gm liver
Germfree	6.7 (12) ±0.1	6.8 (21) ±0.1	0.27 (5) ±0.04
Conventional	6.7 (12) ±0.1	9.1 (18) ±0.3	0.53 (4) ±0.04

( ) Number of samples.

Liver data, however, show the reverse of that found for the hearts. Thus the livers of adult germfree and conventional rats are approximately the same weight (3500 mg%), but data in Table 1 shows that the amount of thiamine dihydrochloride/gm liver tissue in the germfree animal is 6.8 µgm while the amount in the conventional rat harboring a normal flora is 9 µgm. Furthermore, the regional blood flow to the liver of the conventional animal—0.53 ml/min./gm—is much greater than the flow to the liver of the germfree—0.27 ml/min./gm (6).

Data in Table 2 indicate that the levels of thiamine in the hearts of growing germfree and conventional animals (age 6-7 weeks) on diets containing various, but suboptimal amounts of thiamine, were again comparable. The livers of conventional animals however, generally contained more thiamine/gm tissue than livers of germfree animals when the amount of thiamine in the diet was the same. At the 8.8 µgm thiamine/gm diet level (a more than optimal amount for normal growth),

TABLE 2

Thiamine in Livers of Growing Germfree and Conventional Rats Fed Increasing Amounts of Thiamine in the Diet. Age: 6-7 Weeks.

	Thiamine in µgm/gm Tissue			
	Heart		Liver	
Thiamine in Diet µgm/gm	Germfree	Conventional	Germfree	Conventional
0.4	. .	. .	0.4	0.5 ns
0.6	2.1	2.0 ns	0.5	1.0 hs
0.75	2.1	1.9 ns	0.6	1.0 ns
1.1	3.1	2.6 ns	1.0	1.2 s
1.5	3.0	3.0 ns	1.5	2.0 s
8.8	. .	. .	3.7	8.7 hs

ns—non-significant.
s —significant at 5% level.
hs—significant at 1% level.

the amount of thiamine/gm liver tissue in the conventional animal was more than double that found in germfree.

At this point the question poses itself: Is this difference in liver thiamine levels a bacterial production effect—more flora-synthesized thiamine available to the conventional animal or does the liver of the germfree animal require less thiamine because of the absence of a bacterial load effecting the clearance and detoxification mechanisms? The fact that even with suboptimal intake only the germfree liver shows a constantly lower thiamine level seems to indicate that lower requirement rather than lower intake is at the basis of this difference. This is confirmed by the observation that on complete diets, where the contribution of flora-synthesized thiamine to the host was proven to be negligible (5), the same difference exists.

A greater regional blood flow to the liver of conventional animals indicates that more O_2 is needed for the biological oxidation processes, presumably resulting in more chemical energy via catabolism to cover the energy requirements of the liver for clearance and detoxification of materials of bacterial origin. The importance of thiamine as thiamine pyrophosphate in these biological oxidations cannot be over-emphasized. It is known that thiamine is a component of at least 25 enzyme systems. Thiamine pyrophosphate (TPP) for example acts as a coenzyme in the removal of CO_2 from pyruvic acid at the end of the Embden-Meyerhof scheme of glucose metabolism. It is also a necessary component of several enzymes employed in the Krebs cycle and plays a significant role as a transketolase in the direct oxidative pathway of glucose. Analysis of liver transketolase by J. Green using ribose-5-phosphate as a substrate has shown no significant difference in organ content of germfree and

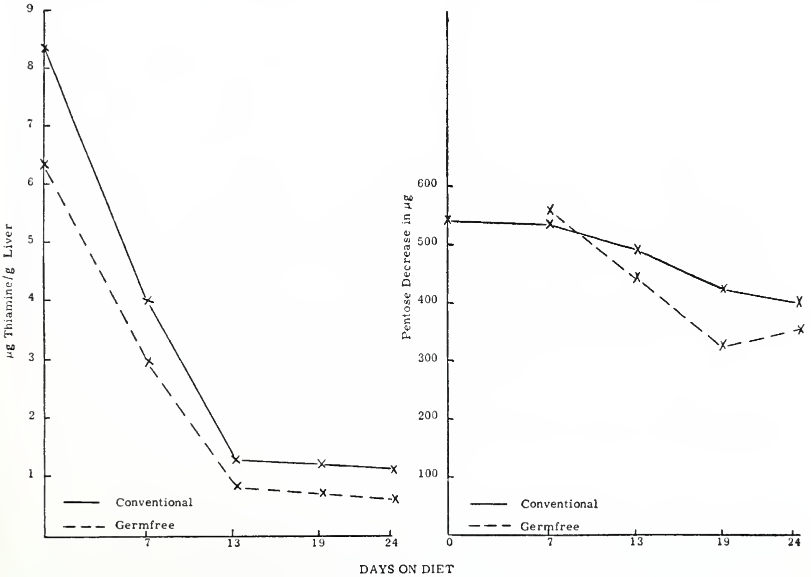

Figure 1

conventional rats. Data in Fig. 1 (a comparison of thiamine content and transketolase activity of the liver in germfree and conventional rats on a thiamine deficient diet) show that the thiamine levels after six days have dropped considerably in both germfree and conventional, while in conventionals the transketolase activity has not changed significantly during that time. Incomplete data at this time seems to indicate that transketolase activity in the liver of germfree rats after six days on the diet follows essentially the same pattern as that of the conventional. Only severe thiamine depletion of the liver causes the transketolase activity to decrease.

Assuming the lower thiamine level of the liver of the germfree rat is an expression of a reduced need for one or more thiamine pyrophosphate containing enzymes, it appears that transketolase is not the limiting enzyme in the energy production for the clearance and detoxification. The lower energy requirement of the germfree liver, expressing itself in lower thiamine levels and less regional blood flow to the liver than is seen in conventionals presumably manifests itself in the reduction of one or more of the other thiamine containing enzyme systems than that of transketolase. The data do express, however, the importance of sufficient thiamine uptake to maintain adequate enzyme levels, which will meet the requirement of the liver to maintain optimal functional capacity.

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Fig. 1. Comparison of thiamine content and transketolase activity of the liver in germfree and conventional rats on a thiamine deficient diet.

Antibody Formation in Germfree Chickens[1]

BERNARD S. WOSTMANN and GEORGE B. OLSON, University of Notre Dame

Introduction

Germfree animals are characterized by an underdevelopment of the lymphoid tissues (2). In the germfree chicken, fewer plasma cells and secondary nodules are found, and the serum gamma globulin concentration is less than that found in the conventional bird (6). The available lymphoid tissue has, by virtue of the germfree state, never been exposed to the specific and non-specific stimuli of a viable microbial flora and its metabolites. In this study we investigated how such a tissue will react to the challenge of a single injection of bovine serum albumin (BSA). This entailed a comparison of anti-BSA precipitin production and serum gamma globulin levels in germfree and conventional chickens. Later, in one of the experiments, we also determined the turnover of gamma globulin in both groups after in vivo labeling with glycine-$C.^{14}$

Materials and Methods

Adult 90-110 days old male and female white Leghorn germfree and conventional chickens derived from the same egg clutches were sensitized with 40 mgm BSA/Kgm body weight. For one month the animals were bled on subsequent designated days from the cupital vein to obtain 1 ml of anti-BSA chicken plasma.

Antibody determination was done using the Preer double diffusion agar gel technique (5). The data obtained with the Preer technique was converted to a quantitative mgm% antibody basis via the following standardization procedure. In one experiment, germfree and conventional anti-BSA chicken plasmas were collected on designated days in a sufficient amount to enable both Preer tests and quantitative precipitin tests to be made. The quantitative precipitin tests were done in the manner described by Banovitz et al. (1). For the Preer test, all antiplasmas were tested with three dilutions of BSA (6.0×10^{-2} mgm BSA/ml, 3×10^{-2} mgm/ml and 1.5×10^{-2} mgm/ml) in triplicate to insure obtainment of proper antigen/antibody rates. The antigen dilution that produced satisfactory Preer factors for all antiplasma samples was chosen for correlation with the quantitative precipitin results. Then, the Preer factor was plotted on semi-log paper against the quantitative amount of antibody for each antiplasma sample to establish the relationship. The values obtained with the germfree and with the conventional chickens showed the same straight line relationship. Hence, Preer factors (obtained with that antigen dilution) for all anti-BSA chicken plasmas obtained during the course of antibody production were transposed to mgm% antibody.

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[1] This research was supported specifically by the National Science Foundation by Grant G-13146, also generally by the Office of Naval Research and the Army Surgeon General (Contract NONR-1623-04), by National Institutes of Health (Grant AM 00566-10) and by the University of Notre Dame.

Electrophoresis to determine gamma globulin fluctuations during the antibody production period was done using cellulose acetate paper and a Sodium Barbital buffer of pH 8.6 and ionic strength of 0.06. Recordings were made using the Photovolt Densitometer and values were converted to mgm% protein. Protein values were determined by the Kagen falling drop method.

Half-life determination of conventional and germfree chicken gamma globulin was done in vivo using glycine 1-C-14. Eighty microcuries were injected into the cupital vein and animals were bled on 1, 2, 3, 5, 7, 9 and 12 days after injection. All plasma samples were fractionated at 33⅓% $(NH_4)_2SO_4$ saturation to obtain the gamma globulin. This fractionation process was repeated four times and the final product was tested for purity by agar gel electrophoresis. The gamma globulin was dialyzed against 1% NaCl at 4°C until absolutely free of $(NH_4)_2SO_4$. Measured aliquots were precipitated on planchets under infra-red light. Radioactivity was determined and protein nitrogen of the sample was determined by Kjeldall digestion and Nesslerlization, and results recorded as cpm/mgm protein. All values were recorded on semi-log paper to determine the gamma globulin half-life.

Results

The data on anti-BSA precipitin production are depicted in Figure 1 and Table 1. They show that in the conventional group, precipitating antibodies are detected on the fifth day after BSA administration, presumably the time when detectable amounts of BSA have been eliminated

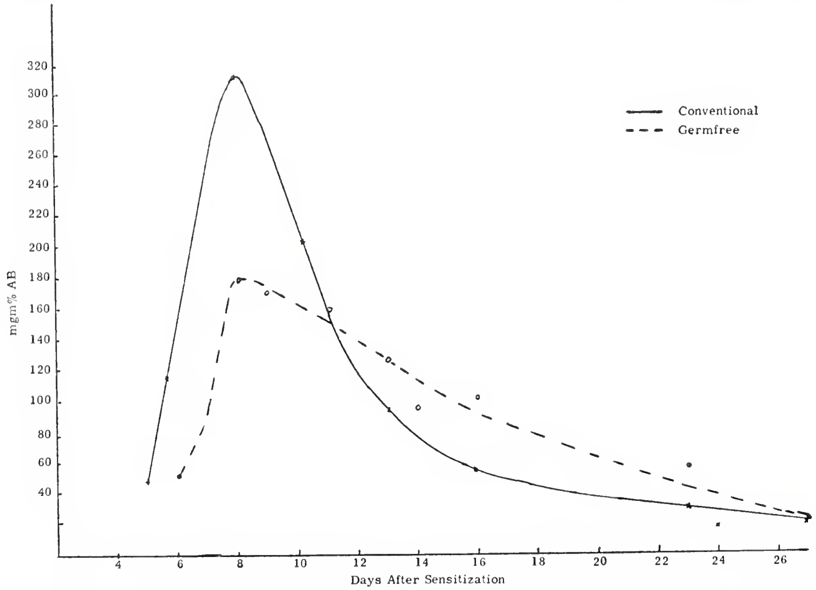

Fig. 1. Comparison of anti-BSA precipitin production in germfree and conventional chickens.

TABLE 1

Ratio of Number of Positive Percipitin Plasmas to Total Number of Samples*

Days After Sensitization	Germfree	Conventional
4	0/6	0/12
5	0/6	8/15
6	5/11	15/15
7	11/11	15/15
9	12/12	14/14
13	7/7	14/14
16	7/7	13/14
20	7/7	12/14
27	2/6	4/8

* Numerator=number of positive precipitin plasma.
Denominator=number of animals bled.

from the circulation. Peak titers are reached 3 days later, after which antibody production declines rapidly. This response agrees entirely with the findings of Wolfe et al. (9) and Patterson et al. (4). In the germfree birds the antibody can be detected by the sixth day, but peak titers are reached at approximately the same time after sensitization as in the conventional chickens. Possibly in agreement with the lower amount of lymphoid tissue originally present, peak titers reach about one-half the values found in the conventional animals. However, decline of antibody concentration is much slower in the germfree birds.

The total increase in gamma globulin over presensitization levels, brought about by the BSA challenge, presents a different picture than in the case of precipitating antibody. Within the limits of error the response in both groups seems comparable (Table 2). Comparing antibody and gamma globulin production especially at peak titer, obviously less of the gamma globulin increase can be accounted for as a precipitating antibody in the germfree group.

After peak titers have been reached, both gamma globulin content and antibody titers decrease, but the decline in antibody titer was found to be much slower in the germ free than in the conventional groups. A determination of the half-life of gamma globulin during a subsequent experiment depicted no difference in metabolic degradation of this protein. Within the limits of error, the values were the same in both groups with 4.2 days for germfree and 4.3 days for conventional birds.

The slopes of the precipitin curves (Fig. 1) taken between the eighth and twentieth days indicate the difference in recession of antibody titers. When charted on semi-log paper they reveal that the half value factor of 7.5 days for germfree animals is twice that of the conventional animals (Fig. 2) while the factor for the latter group agrees within limits of error with the half-life of the gamma globulin for both groups.

TABLE 2

Gamma Globulin and Precipitating Antibody (Ab) After Sensitization With 40 mgm BSA per Kgm Body Weight. Number of Observations in Parenthesis. S.D.M. Values Given.

Day	Germfree				Conventional			
	γ glob.	Δ γ glob.*	Ab	Ab/Δ γ glob.	γ glob.	Δ γ glob.*	Ab	Ab/Δ γ glob.
	mg%	mg%	mg%	%	mg%	mg%	mg%	%
0	469 (5) ±36	0	0	. . .	862 (5) ±47	0	0	. . .
4	643 (5) ±50	174	0 (6)	0	947 (5) ±111	85	0 (12)	0
8	865 (5) ±90	396	179 (7) ±27	45.5	1314 (5) ±117	479	311 (14) ±45	64.5
16	697 (5) ±56	228	101 (7) ±24	44.3	1070 (5) ±119	208	53 (13) ±9.4	25.5

* Increase in gamma globulin level over 0 day value.

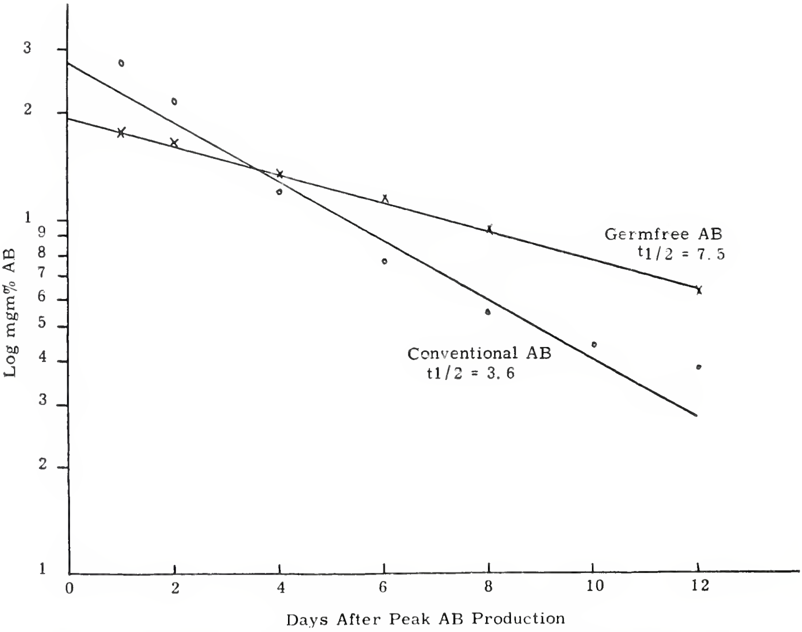

Fig. 2. Comparison of half value factors for degradation of BSA precipitin antibodies in germfree and conventional chickens.

Discussion

Previous literature reports that in the germfree chickens the reticuloendothelial system (RE) is deficient to the extent that less plasma cells and less secondary nodules are found in the spleen, liver, thymus, ileocecal-colic junction and ceca (6). These underdeveloped potentialities may be interpreted to mean that germfree animals have less ability to react to an antigenic stimulation and therefore may be more susceptible to a microbial attack. Early research with chickens monoassociated with *Streptococcus fecalis* and *Clostridium perfringens*, demonstrates that the RE system can react to such stimulation and provide protection, but the sequence of cellular and humoral changes leading to this protection was not recorded (7, 10). Figure 1 and Table 1 both demonstrate the duration and magnitude of circulating precipitin titers in germfree and conventional chickens, sensitized to a relatively simple antigen, and show that the response of the humoral defense mechanism of the germfree birds differs from that in conventional animals in three aspects.

First, the conventional animals are able to produce a detectable level of precipitins quicker than the germfree chickens. This 24 hour difference in detection could be attributed to the original underdevelopment of the RE system of the germfree and the actively conditioned state of the conventional system. The conventional RE system has been subjected to antigenic attack since the early days of life and consequently many of its more exposed elements have obtained a well developed cellular level in comparison to those in the system of the germfree birds. It is recorded that antibody production is dependent upon the mitotic division of immature pyroninophilic cells and their subsequent development into antibody producing entities (8). Hence, in conventional animals, this mitotic division of antibody forming cells with the resulting geometric progression may furnish a detectable antibody level earlier than does the germfree's lower quantity of untrained cells.

The second difference in the antibody response is concerned with the quantity of precipitins produced at the peak of circulating antibody response. Although the germfree group demonstrates a 24 hour delay in detectable response, it reaches its peak titer on the eighth day as does the conventional animal, but at that time depicts approximately one-half the amount of antibodies produced in the conventional system. Again this difference suggests a greater proliferation of cells with a specific anti-BSA antibody potential in the conventional animals.

The third distinction between the two responses is concerned with the disappearance of detectable antibodies from the circulation. Here the conventional group follows the well defined literature values of declining sharply in concentration right after the day of peak titer, but in the germfree animals the antibody concentration shows a more gradual decline. The conventional half value factor falls within the determined gamma globulin half-life time of four days, while the half value factor for the germfree animals shows a much higher value of 7.5 days. Antibody degradation thus becomes quite evident in both groups after the eighth day but the slope of the lines in Figure 2 suggests that as antibody production virtually ceases in the conventional group, it continues to a certain extent in the germfree chickens.

One possible explanation for this difference is that the RE system of the germfree BSA sensitized animal reacts to only one antigen, and once this antibody producing mechanism is stimulated it will produce until it becomes metabolically inert, whereas the RE system of the conventional bird is constantly being subjected to environmental antigenic stimulations. Therefore, some of the potential BSA-antibody producing cell lines may encounter an additional, more demanding antigen during or following mitotic division, which suppresses the BSA-antibody instruction, and stimulates the cell line to produce a second type of antibody.

This reasoning is in accordance with the concept that a cell can only produce one antibody at one given time (3). Hence, the conventional system becomes deprived of an elevated, longer lasting antibody titer because of competitive interactions of different antigenic stimuli for the existing or potential antibody producing cells.

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BOTANY

Chairman: PAUL WEATHERWAX, Indiana University and Franklin College

J. H. Maysilles, Hanover College, was elected chairman for 1963

Genetics and Biochemistry of the "Dark-eye" Phenotype in *Impatiens balsamina* L. ELEANOR S. KUTLICH and CHARLES W. HAGEN, JR., Indiana University.—The "dark-eye" race of *Impatiens balsamina* originated from open-pollinated seed collected in a Bloomington garden. By selection, a true-breeding race was established which approached in appearance the inbred genotype $llhhP^rP^r$. In the F_1, resulting from the cross white llhhpp), isogenic with $llhhP^rP^r$, to the "dark-eye" race, the following characteristics of the "dark-eye" race appear dominant: pigmentation of the upper stem, deep red foliar nectaries, red midribs, bluish-red pigment of petal bases, and intense sepal color. In the F_2, nectary color segregated independently, whereas color of the upper stem, midribs, sepals, and petal bases were associated. The characteristics associated with the "dark-eye" race also segregated independently of the gene P^r, but were not expressed in the presence of the gene p. Intensity of pigmentation is reduced in hybrids, probably as a result of heterozygosity at the P^r locus. Chromatographic analyses reveal pelargonidin as the only anthocyanidin in petals of the genotype $llhhP^rP^r$, whereas the sepals contain cyanidin, peonidin and traces of pelargonidin. In the "dark-eye" race, pelargonidin and total anthocyanidins are increased in the sepals. Cyanidin and peonidin occur in the petals along with pelargonidin, the cyanidin and peonidin being concentrated at the base and diminishing toward the edge. This distribution, which characterizes the "dark-eye" phenotype, suggests that the responsible gene operates to spread precursors of the pigments or the ability to produce individual pigments into regions not involved in the inbred genotype $llhhP^rP^r$.

Differential Temperature Effects for Identification of Wheat Leaf Rust Resistance Combinations. L. B. JOHNSON and J. F. SCHAFER, Purdue University.—The resistant wheat varieties Frontana and La Prevision 25 exhibited more susceptible reaction types to races 1 and 2 of *Puccinia recondita* Rob. ex Desm. at 80 than at 60°F. Reaction types of Aniversario increased from 60 to 80 only with race 2. Highly resistant selections from the crosses Aniversario x Frontana and La Prevision 25 x Aniversario behaved as did Aniversario. A La Prevision 25 x Frontana selection followed the pattern of its parents. Aniversario and La Prevision 25 also showed a lesser degree of resistance to race 2 than did Frontana. These results suggested techniques for identifying combined resistance varieties using differential temperature effects. Selections from crosses of La Prevision 25 x Aniversario and La Prevision 25 x Frontana possessing both parental resistances as previously determined by other methods may be crossed, insuring plants having the La Prevision 25 resistance. Testing F_2's with race 1 at 80° and discarding plants with higher than a zero reaction type would leave only those possessing the Aniversario resistance. Moving the plants to 60°, inoculating with race 2, and saving only plants of zero reaction type would leave only those possessing Frontana resistance. These remaining plants would then have resistance from all 3 parents. Repetition of tests on F_3 plants would allow detection of homozygotes.

A Potent *Penstemon* **Pathogen,** *Ramularia nivosa* (Ell. & Ev.) Shaw & Cooke, JOE F. HENNEN, Indiana State College.—Controlled inoculation studies have shown that *Ramularia nivosa* (Ell. & Ev.) Shaw & Cooke is an incitant of a severe leaf and stem blight of various species and hybrids of Penstemons in Indiana. In this region this disease is a limiting factor in the cultivation of many species and hybrids of this valuable ornamental genus. Observations on plants grown in field plots under natural conditions indicate that only six of 38 species seem to have natural resistance to this parasite. These were *P. barbatus, P. ambiguous, P. pinifolius, P. peckii, P. richardsonii* and *P. vaseyanus.* Preliminary cultural studies of the pathogen showed that best vegetative growth occurred at 20°C and malt agar was the best of several different media used.

Bryophytes of Cabin Creek Raised Bog

WINONA H. WELCH, DePauw University[1]

The Cabin Creek Raised Bog, discovered and named by Ray C. Friesner and J. E. Potzger (2), occurs in Randolph County, Indiana, along State Highway 1, six miles north of Modoc and three miles south of Farmland. They gave it this name because of its location in the floodplain of Cabin Creek. These botanists determined that the central portion of the convex mass is 10 ft. above the floodplain, that the entire region is glaciated terrain, dating to the activity of Early Wisconsin glaciation, and that the bog is about 50 miles south of the limits of the Late Wisconsin glaciation in Indiana. Of the three types of raised bogs in America, they reported that the Cabin Creek Raised Bog has been caused by artesian spring water, high in calcium content, with mosses, sedges, and grasses as the chief peat formers. This type of bog occurs in inland areas. In addition, Friesner and Potzger stated that Cabin Creek Raised Bog is an example of a raised bog formed by weakly expressed hydrostatic pressure causing wet areas favorable to luxuriant growth of mosses *(Drepanocladus)* as well as growth of sedges and grasses, and that the accumulating remains will form an ever-deepening layer of peat which will gradually build up a convex mound.

By means of 73 borings and an intensive two-year study, the following information was contributed by Friesner and Potzger. They found no open water beneath the peat but a fairly compact mass of peat through which water was forced by some head pressure. From their findings they assumed that originally there was a deep, water-filled hole in an ancient stream bed and that the early filling was due to water-deposited, finely divided material, composed mainly of inorganic particles and marl. Their borings gave evidence of small pieces of wood, a few leaves of mosses and parts of sedges, mixed with this deposit at the 13-foot level. From the 12-foot to the 8-foot levels mosses and sedges contributed the organic sediment constituents, according to the Butler University botanists, and from the 7-foot to the 1-foot levels peat was formed chiefly by wood. Their boring 7 was made in the deepest part of the bog. In boring 7, at 8-foot level, the sediment was chiefly moss-sedge, at 12-foot level, moss-sedge; in boring 1 (all on land), moss was found from 13-foot to 8-foot levels; in boring 5, moss occurred in sediment from 10- to 7-foot levels. In summary, the moss fragments occurred from 13- to 7-foot levels, below 13, very little organic matter, above 7, mainly wood or sedge, or wood and sedge.

In their boring 1, the sandy soil is abruptly overlain by 3 feet of a coarse, raw *Drepanocladus* (determined for Friesner and Potzger by W. C. Steere) peat. In the great majority of borings they had evidence

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[1] The author is indebted to the Graduate Council of DePauw University for a grant in aid of research.

of abundant marl. The absence of ericads, plant indicators of acid substratum, is also indicative of the alkaline habitat.

The data obtained from their studies of borings at different foot-levels showed retardation of peat formation as the bog increased in height and apparent increased evaporation rate, resulting in increased oxidation of plant remains.

The several small streams which flow from the peat moss at the present time arise at the artesian springs.

The writer has followed the classification of bogs as fens if the habitat is alkaline.

On June 16, 1962, the author visited the bog[2] to collect bryophytes for the preparation of records of the mosses and liverworts presently growing in the Cabin Creek Raised Bog. The areas cited are those used by W. A. Daily in his report (1) of the algae occurring in the bog: Spring Area 1, Spring Area 2, and the Knoll. Sixty collections were made at random, assuming that this method would produce the species and the associations of the bryophytes now occurring in this bog.

According to W. A. Daily, the temperature of the water at the opening of the artesian springs is ± 52°F throughout the year, and the pH Value of the bog water is ± 7.

Gordon (3) reported two mosses in the Urbana Raised Bog: *Anomodon rostratus* and *Tortella caespitosa.*

Neither *Drepanocladus* reported by Friesner and Potzger nor *Anomodon* or *Tortella* recorded by Gordon were found in the author's 60 collections.

The only hepatic collected was *Riccardia pinguis* (L.) S. F. Gray. This hygrophytic liverwort occurs with the mosses, growing in between the plants, on soil at base of spermatophytes, as well as on crusty, alkaline soil at margin of the stream and extending into water. It occurred in 6 collections. In 1961, Fay K. and W. A. Daily sent a specimen to the writer for determination.

Campylium stellatum (Hedw.) Lange & C. Jens. was the most common moss in the fen, occurring in 37 of the 60 collections. It grows in large sods at base of spermatophytes, alone, or with other mosses, in Spring Area and on Knoll. This moss either prefers or is tolerant of fens and apparently has had a prominent part in filling up bodies of water such as quaking bogs, by growth upon the ground and by aiding in the formation of a surface mat. *C. chrysophyllum* (Brid.) Bryhn was found in one collection, in Spring Area 2.

Bryum creberrimum Tayl. [formerly *B. cuspidatum* (B.S.G.) Bryhn] was growing in the three areas, Spring Areas 1 & 2, and on the Knoll, and occurred in 11 of the 60 collections. *B. pseudotriquetrum* (Hedw.) Schwaegr. grows in both Spring Areas and was collected twice. On Sept. 23, 1961, W. A. & Fay K. Daily collected it in Spring Area 1.

Fissidens adiantoides Hedw. was collected in Spring Area 2 and on the Knoll, occurring in 13 collections.

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[2] The leader of the Cabin Creek Raised Bog foray was Wm. A. Daily. Other members of the excursion were Fay K. Daily, T. G. Yuncker, Charles and Joan Hall, Mr. and Mrs. Robert Holliday, Mike Holliday, and the writer.

Rhynchostegium serrulatum (Hedw.) Jaeg. [formerly *Eurhynchium serrulatum* (Hedw.) Kindb.] occurs in each of the three areas, and was found in 5 collections.

Each *Hygroamblystegium tenax* (Hedw.) Jenn. [formerly *H. irriguum* (Wils.) Loeske] and *Cratoneuron filicinum* (Hedw.) Roth occur in 6 collections. *Hygroamblystegium* was found in both Spring Areas and *Cratoneuron* was collected in Spring Area 2. *C. filicinum* grows especially in calcareous areas and is regarded as an important plant in the forming of tufa.

Pleurozium schreberi (Brid.) Mitt. [formerly *Calliergonella schreberi* (B.S.G.) Grout] was collected once, in Spring Area 2; *Mnium affine* Bland. once, in Spring Area 1; and *Ceratodon purpureus* (Hedw.) Brid. once, on the Knoll.

At least eleven species of mosses and one species of hepatics occur in the Cabin Creek Raised Bog at this time. These species occur in the following bryophyte associations in this fen: *Bryum creberrimum & Campylium stellatum; Bryum creberrimum & Fissidens adiantoides; Campylium chrysophyllum & Fissidens adiantoides; Campylium stellatum, Bryum creberrimum, & Fissidens adiantoides; Campylium stellatum & Bryum pseudotriquetrum; Campylium stellatum & Cratoneuron filicinum; Campylium stellatum & Fissidens adiantoides; Campylium stellatum & Rhynchostegium serrulatum; Campylium stellatum & Riccardia pinguis; Campylium stellatum, Riccardia pinguis, & Fissidens adiantoides; Ceratodon purpureus & Campylium stellatum; Cratoneuron filicinum & Bryum pseudotriquetrum; Fissidens adiantoides, Campylium stellatum, & Pleurozium schreberi; Hygroamblystegium tenax, Bryum creberrimum, Cratoneuron filicinum, & Fissidens adiantoides; Hygroamblystegium tenax & Rhynchostegium serrulatum; Rhynchostegium serrulatum, Campylium stellatum, Bryum creberrimum, & Fissidens adiantoides; Rhynchostegium serrulatum & Fissidens adiantoides;* and *Riccardia pinguis, Cratoneuron filicinum, & Campylium stellatum.*

Among the mosses of Cabin Creek Raised Bog, *Campylium stellatum* and *Cratoneuron filicinum* are regarded as indicators of calcareous habitats, supporting the previous findings by the absence of ericaceous plants and by chemical tests, and the classification of this bog as a fen. From the evidence of the frequency of *Campylium stellatum* alone or in bryophytic associations, the author has concluded that it is the chief bryophyte factor in the present stage of development of the Cabin Creek Raised Bog and in the plant life of the fen.

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3 Gordon, Robert B. 1933. A Unique Raised Bog at Urbana, Ohio. The Ohio Journ. Sci. **33**(6):453-459.

Indolebutyric Acid Failed to Aid Black Walnut Seedling Development

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Agriculture, Forest Service, Central States Forest
Experiment Station, Bedford, Indiana

Various growth regulators have proved helpful for rooting cuttings and some have improved root growth of transplanted seedlings (3) (4).

Survival and growth of black walnut (*Juglans nigra* L.) seedlings in old-field plantings have been poor. A recent black walnut planting survey in Indiana (2) showed that average survival for planted black walnut seedlings was 44 percent. Many nursery-grown black walnut seedlings develop tap roots with few secondary roots so it seemed that stimulated secondary root growth would aid survival and top growth of transplanted seedlings.

In a recent study neither secondary root growth nor survival and height growth of transplanted black walnut seedlings were greatly improved when the roots were soaked in low concentrations of indolebutyric acid.

Methods

Nursery-grown black walnut seedlings were placed in 10-quart pails with enough liquid to cover the pruned, 8-inch root systems. Treat-

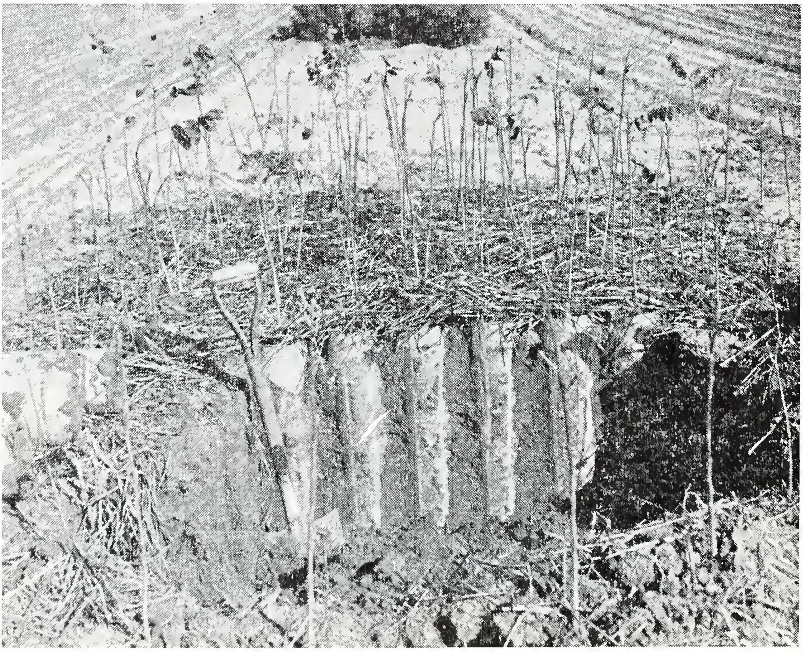


Figure 1.—Seedlings were grown in stove-pipe pots to facilitate root recovery.

ments included five water solutions containing 10, 20, 40, 80, and 640 parts indolebutyric acid per million parts water and one tap water control. Seedlings in the 640 parts indolebutyric acid per million treatment were "dipped" for 45 minutes but in the other treatments seedlings were soaked for 24 hours. Five replications of each treatment were prepared 2 weeks before planting and five more were prepared 1 day before planting. The two treatments were scheduled to simulate treatment at the nursery before shipment and treatment by the planter just before planting. The planting was done in a completely randomized design.

The study was divided into two parts: one a pot study to determine the effects of indolebutyric acid on root growth, the other an old-field planting to find out the effects of IBA on survival and height growth of planted seedlings.

The pot study was conducted at the Vallonia Nursery where the soil is Princeton fine sandy loam. Seedlings were planted in 24-inch

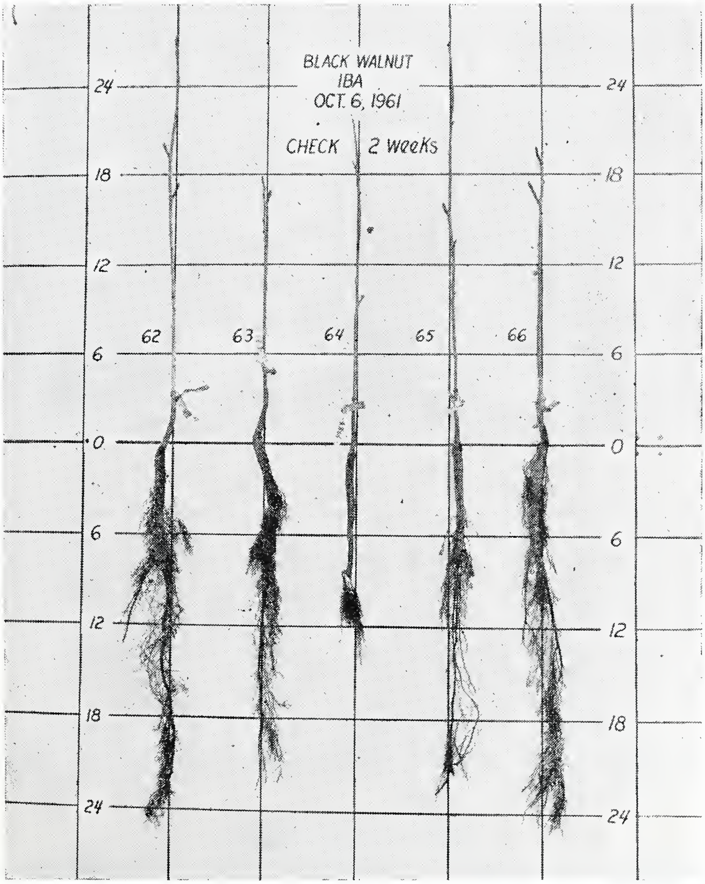
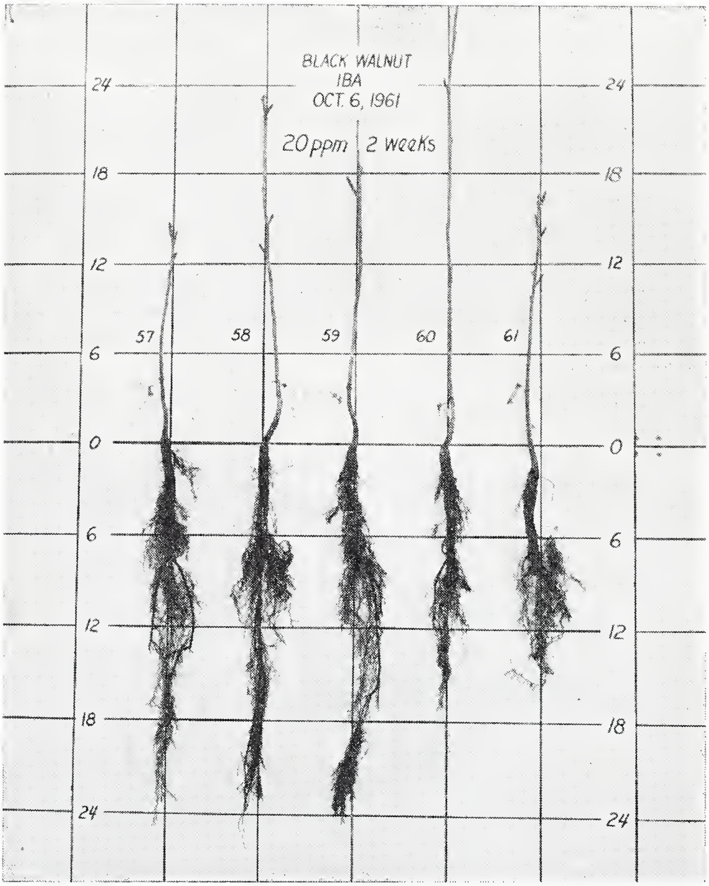


Figure 2.—Root growth of IBA-treated seedlings was slightly better than for the controls. (A) Untreated seedlings; (B) IBA-treated seedlings.



galvanized stove-pipe pots to facilitate recovery of the root system at the end of the growing season (1) (fig. 1). To approach natural soil temperature, the pots were buried with about 1 inch protruding above ground level. Top soil, kept separate during the excavation, was used to fill in around the roots of planted seedlings. All seedlings were mulched to conserve soil moisture. Sixty seedlings, one in each pot, were carefully measured and photographed before planting in the field and after the growing season.

The old-field plots border an intermittent stream on silty clay loam soil in Orange County, Indiana. An old field was selected for the planting site in order to study the treatments under severe conditions. Sixty 10-tree plots were planted.

Results and Discussion

One-year root growth of transplanted black walnut seedlings, as determined by root volume and weight of potted seedlings was not greatly improved by any of the indolebutyric acid solutions. Secondary root growth of acid-treated seedlings was slightly better than for the controls but differences were not statistically significant (fig. 2). Root growth was not affected by treating the seedlings either 2 weeks or 1 day before planting.

Second-year results of the old-field planting showed that indolebutyric acid did not increase survival or growth of black walnut seedlings on old-field sites. Survival of all stock, regardless of treatment, was excellent and ranged from 94 to 99 percent. Survival of seedlings treated 2 weeks before planting was 96 percent compared with 97 percent for seedlings treated 1 day before planting.

Two-year height growth was very poor. Dieback, characteristic of planted black walnut seedlings, occurred both years. Growth would have been better on a more favorable forest site. But on the old field indolebutyric acid neither helped nor hindered height growth and it is a matter of conjecture whether IBA would have been more effective on a better site.

These results indicate that indolebutyric acid was relatively ineffective in stimulating secondary root growth of black walnut seedlings and it did not aid survival and height growth of field-planted stock.

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White Ash, Hackberry, and Yellow-Poplar Seed Remain Viable when Stored in the Forest Litter

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Tree reproduction following several experimental harvest cuttings showed that yellow-poplar (*Liriodendron tulipifera* L.) and white ash (*Fraxinus americana* L.) seeds probably remain viable beyond the normal germinating period. Cuttings in Indiana and Ohio resulted in excellent stands of yellow-poplar seedlings in the absence of a current seed source. In 1958 the white ash seed crop was a complete failure on southern Indiana plots. Yet transect surveys of reproduction revealed that many ash seedlings became established during the 1959 growing season. These seedlings originated from seed stored in the litter. McCarthy (1) cited two cases where yellow-poplar seed remained dormant at least 1 year. Williams and Mony (3) found that yellow-poplar remains viable at least 3 years in nursery stratification pits. Seeds of several ash species are known to remain viable under specific storage conditions (2). The ability of tree seed to remain dormant in the forest litter beyond the normal germinating period could be a valuable asset to the silviculturist. In 1957 a study was begun to find out if seed storage takes place under natural conditions.

Study Methods Simulate Natural Conditions

The original experimental design included only yellow-poplar but in 1959 the study was expanded to include white ash, hackberry (*Celtis occidentalis* L.), and sassafras (*Sassafras albidum* (Nutt.) Nees). The study was designed primarily to simulate natural conditions. The seed "storage" area is in Orange County, Indiana within a fully stocked upland hardwood sawtimber stand having a good accumulation of leaf litter. There were no seed trees of the species studied adjacent to the storage area.

The storage area was fenced with 4-foot, ¼-inch mesh hardware cloth to exclude large animals. However, this enclosure was not rodent, bird, or insect proof. The storage area was divided into 3-foot square subplots. Seedlots of the species tested were broadcast sown directly on the subplots to simulate natural seedfall (fig. 1). Four subplots (replications) were randomly assigned to each year that seed was scheduled for germination tests. On the scheduled dates, loose litter from the designated subplots was carefully removed and discarded. The humus and about ½ inch of the A horizon was collected in containers. This mixture of stored seed, humus, and mineral soil was sown on scarified, germination subplots in a forest opening. Unseeded, control subplots were treated in the same manner to account for volunteer seed in storage and germination subplots. Only a few volunteer seedlings were found throughout the entire study. All sowing was done in the fall and first-year seed was sown directly on the germination subplots.

Seedling counts were made bi-weekly during the normal germination period.

Figure 1.—The seed was broadcast sown on top of the litter in storage subplots.

Cutting tests of the two-seeded yellow-poplar samaras averaged 19.2 filled seed per 100 samaras. One thousand yellow-poplar samaras were sown in each subplot. Soundness tests for the other species were as follows: white ash, 99.5 percent; sassafras, 96 percent; and hackberry, 100 percent. Each storage subplot received 200 white ash, 50 sassafras, and 100 hackberry seeds.

Natural Seed Storage Clearly Demonstrated

After four winters in storage, yellow-poplar seed was still germinating at the rate of 4 seedlings per 100 samaras. The number of seedlings per 100 samaras was: 7.2, 8.4, 3.5, and 4.0 for one, two, three, and four winters in storage. During the course of the study yellow-poplar seedlings were recorded in many of the storage subplots. Evidently some seed lodged in locations favorable for germination. In the undisturbed forest floor seed probably reaches favorable position for germination through the process of litter and humus decomposition. Germination takes place when the seed remains constantly moist for several weeks at the proper temperature. By the time most yellow-poplar seed reaches favorable position for germination it is likely covered by a barrier of fresh-fallen litter. Also, the seed is continuously subject to predation by insects and rodents.

First-year germination for white ash, sassafras, and hackberry was 38, 12, and 34 percent, respectively. After two winters in storage germination was as follows: white ash, 38 percent; sassafras, 0 percent; and hackberry, 20 percent. So sassafras deteriorates rapidly in natural storage but ash and hackberry seeds will remain viable for some time. Ash and hackberry seedlings have been recorded in the storage subplots 2 years beyond the normal germinating period.

The germination percentages merely indicate trends. In nature many factors influence the longevity of a particular seed crop. Viability likely varies widely with the moisture regime of the litter and many things influence litter moisture. The use of forest-opening seedbeds introduced additional natural variation into the study. But, there is little doubt that viable yellow-poplar, white ash, and hackberry seed will accumulate in the forest litter for several years.

Results Useful

Results of this study can be used to improve hardwood silviculture. Knowing that the seed of various species will remain viable for several years, the forester or forest manager should be able to improve composition in the new stand. For yellow-poplar, white ash, and hackberry, the current seed crop does not necessarily dictate the time of cutting. The forest manager has at his disposal a reservoir of seed stored in the forest floor rather than just a fresh layer of seed on top of the litter. There appears to be no good reason to perpetuate the classical seed-tree method of harvest cutting yellow-poplar. While some will argue that seed trees are insurance, it is simply poor business to recommend that valuable trees be left standing to provide an ineffective seed source. Seedbed treatments to increase the amount of yellow-poplar reproduction can be undertaken with more confidence, especially near the perimeter of the effective seeding range of the seed source.

There is a need to find out what happens to seed viability of both desirable and undesirable species. The influence of seed predators and weather conditions on dormant seed needs to be evaluated. While it is the goal of the silviculturist to increase the amount of desirable species in the new stand, he must also consider the density of undesirable species. Without doubt there are unwanted trees and shrubs that produce seed that will remain dormant in the litter. Such species as blackgum (*Nyssa sylvatica* Marsh.), dogwood (*Cornus florida* L.), and redbud (*Cercis canadensis* L.) are prime suspects. If the seed of such species accumulates and remains viable for a number of years, seed sources must be eliminated from the forest stand years ahead of the harvest cut.

This study has served to demonstrate that tree seed, like the seed of many other plants, will remain viable over a period of years under natural conditions. Through careful planning the forester may be able to take advantage of this basic information to improve various forest practices.

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Bioassay Methods for Geotropically Active Growth Substances

ARTHUR H. WESTING,[1] Purdue University

In conjunction with a study of the hormonal mechanisms involved in the geotropic reactions of conifers, it was felt necessary to develop a means of testing substances for their ability to modify geotropic activity. The tests that are commonly employed for uncovering auxin activity were not considered suitable here since they are designed to test for straight-growth activity.

It was decided to base the geotropic test on the ability of immature oat coleoptiles to begin a rapid geotropic recovery when severed and oriented horizontally, such recovery occurring as a result of a relatively lesser cell elongation on the upper side. The oat coleoptile, of course, has long been a favorite organ of the physiologist. Brighton oats[2] were chosen because they are a hull-less cultivar of comparatively uniform growth.

Coleoptiles for the assay are produced in a "dark" room continuously illuminated with dim red light having wavelengths longer than about 660 mμ,[3] a tropistically inactive region of the spectrum. Seeds are soaked for two hours in aerated distilled water, rinsed briefly, and sown on several layers of water-saturated Scotties brand facial tissues. The seeds are then germinated at 22-24°C in moisture-saturated chambers. The germination is carried out under the same continuous dim red light used above which, while tropistically inactive, does suppress the growth of the first internode in favor of the coleoptile. After 70-71 hours, coleoptiles are collected from among vertically straight, 27-30 mm long individuals. The primary leaf is extracted and the apical 20 mm of each coleoptile is retained.

The excised coleoptiles, kept in the "dark" room, are next mounted horizontally (skewered) to a support[4] by their basal (proximal) end so that their vascular bundles are oriented one above the other.

Coleoptiles, prepared as above (and still kept in the "dark" room), are then used in one of three ways. In two of the procedures they are immersed in an aqueous medium with test substances applied via diffusion from the medium, a method suggested by the work of L. Anker (1). In the first procedure the coleoptiles are left intact, in the second a 1 mm decapitation is performed. In the third procedure, coleoptiles are decapitated and enclosed in a moisture-saturated chamber with the test substances applied to their cut apical end via diffusion from a solidified agar solution, a method suggested by the classical *Avena* curvature auxin assay of F. W. Went.

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[1] The author is indebted to the National Science Foundation for generous financial support (Grant No. 18482) and to Paramajit S. Dhillon for laboratory assistance.

[2] *Avena sativa* L. v. Brighton, obtained from T. Rajhathy, 42 Farlane, Ottawa, Canada.

[3] Red fluorescent tube, G.E. No. F15T8-R-15W, wrapped with ca. 12 layers of red moistureproof cellophane, DuPont No. 300-MSC-RED.

[4] A vertical plexiglass post (with base) to which are cemented at 1 cm intervals several (usually five) 5.5 mm diameter brass (or stainless steel) pins projecting out horizontally 8 mm. Four such supports can be installed conveniently in a 400 ml beaker.

In any case the coleoptiles soon begin elongating and curving upward, the subsequent response generating an apparently linear function with time for at least two hours. The coleoptiles elongate approximately 5 mm during the first 90 minutes, most of this growth occurring in a zone originally 6 to 10 mm back from the tip. The rate of growth and recovery for the decapitated coleoptiles is very slow, no physiological tip regeneration occurring during this time.

Response usually is measured after a 90 minute incubation period. It is recorded photographically[5] and the vertical angular displacement is measured. The angle, whose vertex is at a horizontal distance of 10 mm from the basal end of the section, is generated from the horizontal by an arm extending an additional 10 mm (angle ∝ in Figure 1). Measurement is facilitated by using a protractor with a swinging arm. A typical displacement after 90 minutes of incubation is 27°, and for a decapitated coleoptile, 10°. There is an indication that the response would be more accurately represented by a sine transformation of this angle (line S in Figure 1).

THE MEASURING OF VERTICAL DISPLACEMENT OF 71-HOUR-OLD RED-LIGHT-GROWN OAT COLEOPTILES CUT AT 20 MM, MOUNTED HORIZONTALLY, AND INCUBATED IN THE DARK FOR 90 MINUTES

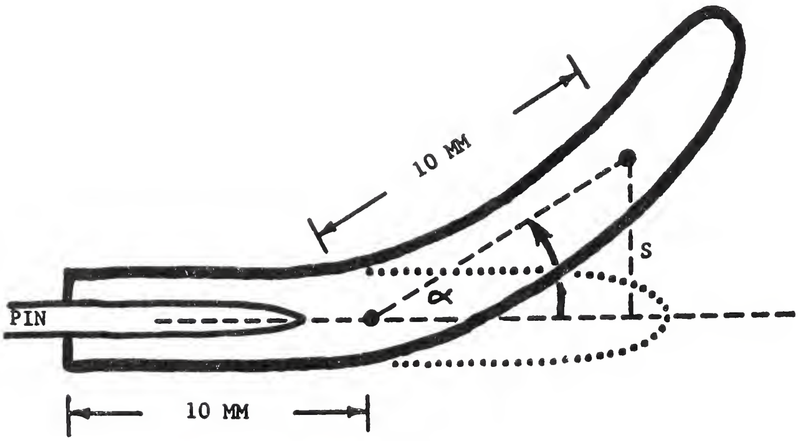

Figure 1

Problems of biological variability besetting the assay are minimized by developing carefully repeated routines of procedure (e.g., beginning each experiment at the same time of day) and by designing each experiment as a self-contained unit with its own controls. Differences in response between controls and treated coleoptiles are tested for significance by an analysis of variance followed by J. W. Tukey's procedure for multiple comparisons, a conservative test (2). A difference of approximately 5° is usually required for significance at the 1% level.

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[5] Shadographs are made using a high contrast photographic paper (Kodak Kodabromide A-5).

In the procedures where the coleoptiles are kept immersed during incubation, the substance (or combination of substances) to be tested is dissolved in the ambient medium. While the hydrogen ion concentration of the medium per se seems to have little effect on geotropic recovery, pH can have a profound influence through its control over the state of ionization of substances being tested. Where it is necessary to control pH, it was found that McIlvaine's buffer system (citric acid/K_2HPO_4) used 1/10 strength could be employed without side effects. When using the method of total immersion either intact or decapitated coleoptiles are used, the two procedures appearing to detect different classes of compounds. For example, indoleacetic acid in the range of physiological concentrations has little if any effect on the geotropic response of intact coleoptiles, but enhances the response of the decapitated ones (optimum concentration, ca. 10^{-7} *M*). On the other hand, an unknown substance extracted from white pine stems (*Pinus strobus* L.) appears to enhance the response of intact coleoptiles while being without effect on decapitated ones. In the third method of application, where the substance to be tested diffuses into the apical end of a decapitated coleoptile from a tiny block of agar,[6] indoleacetic acid is most effective in enhancing the geotropic response at a concentration of ca. 3×10^{-7} *M*.

The agar block technique appears to be suited to disclose activity of the auxin type. However, since a removed tip can be replaced, in effect, only partially by application of indoleacetic acid to the cut stump, this method could conceivably uncover the involvement in geotropism of other tip-produed substances. The method of application via total immersion of the coleoptiles, particularly in the procedure where the coleoptiles are left intact, will perhaps uncover substances capable of modifying geotropic perception or sensitivity.

Summary

Procedures are presented for performing, analyzing, and evaluating an assay to test substances for their ability to influence geotropism. The technique is based on the ability of immature *Avena sativa* L. coleoptiles to begin a rapid geotropic recovery when excised and oriented horizontally, and for this response to be alterable by applications of test substances.

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[6] A 2 x 2 x 1 mm block of 1.5% Difco bacto-agar buffered at pH 4.9.

Some Factors Influencing Rhizoid Formation in Female Gametophytes of the Marsileaceae

William W. Bloom, Valparaiso University

We have been working with various members of the family Marsileaceae for the past twelve years or more and have become interested in rhizoid formation in the megagametophytes. When first observed the rhizoids were seen to arise from the base of the gametophyte adjacent to the region where the root was forming on the enclosed embryo. Rhizoid formation was usually limited to a small region adjacent to the site where the root emerged and the base of the gametophyte next to the megaspore wall. When this close association of position was noted between the root and rhizoids, it was thought that there might be a hormonal relationship between the megagametophyte and the enclosed embryo sporophyte. Time was not available to explore this relationship when first observed, but during the past year some work was done on this problem and the results are very interesting.

It was suggested to an undergraduate student, Stephen Main, working under a National Science Foundation grant for undergraduate research at Valparaiso University that he spend some time studying this gametophyte-sporophyte relationship. Several approaches to the problem were followed.

Sporocarps of *Marsilea Drummondii* A. Br. collected in October, 1953 by Mr. T. R. N. Lothian of Loxton, South Australia were placed in vials containing tap water. Following dehiscence of the sporocarps, but before the microspores had a chance to germinate and produce free sperm, some of the megaspores were isolated and placed in separate vials. Within several days both the megagametophytes which did not possess embryos and the megagametophytes containing embryos were observed to possess rhizoids. In both cases the rhizoids were concentrated in the same regions on the ventral side of the floating gametophytes. This ruled out a hormonal relationship between gametophyte and sporophyte.

The next effort was directed toward determining whether a limited region was involved in rhizoid formation or whether many different epidermal cells of the megagametophyte were capable of forming rhizoids. To determine this, megagametophytes were again isolated before fertilization could occur, as well as after fertilization, and placed on the surface of mineral nutrient agar in Petri dishes. The dishes were kept covered to retain moisture. Once the megaspores were attached to the surface of the agar they adhered firmly. Some of the dishes were kept upright and others were inverted. Under these conditions rhizoids developed on the gametophytes with embryos as well as those without embryos. In all cases, the roots and rhizoids grew downward, regardless as to whether this was into the agar or into the moist air. This suggested that rhizoid formation was possibly controlled by a hormone that became sufficiently concentrated in the ventral position to initiate cell-changes leading to rhizoid formation.

At this point Mr. Main had to discontinue his work on this problem. The author continued further work as time permitted. Since the evidence obtained thus far suggested a hormone which might be moving due to graviational force to the ventral region of the gametophytes, a method was sought which would prevent such concentration, were it occurring. Several flasks of tap water were prepared. In some, sporocarps were dehisced and the gametophytes were permitted to develop overnight, which was sufficient time (sixteen hours) to permit maturation of the gametophytes and fertilization of the eggs. These were then placed on a shaker. In other cases the sporocarps were dehisced in flasks and immediately placed on shakers. Several control flasks were also prepared and used in making observations to detect the appearance of rhizoids. The work was carried on under constant illumination at thirty-six degrees centigrade.

When rhizoids were observed on the controls, the experimental flasks were removed from the shaker and their contents were examined. The megagametophytes which were not placed on the shaker until sixteen hours after dehiscence of the sporocarps showed fairly normal sporophytes and numerous rhizoids, usually in the expected position. The embryo sporophytes were often curved and twisted. In the flasks in which the sporocarps did not open until the flasks had been mounted on the shaker, several differences were noted. Most of the eggs in the megagametophytes had not been fertilized, hence the megagametophytes did not contain embryos. This was probably due to the disturbance of diffusion patterns of chemotactic substances produced in the archegonia or to the inability of sperm to enter the neck canal due to the constant motion of the liquid. Rhizoids were observed completely around the megagametophyte in an extensive region next to the megaspore wall. Many of the megagametophytes showed some abnormality in shape and some gave evidence of extended gametophyte development beyond that usually noted in plants not containing embryos. The extensive development of rhizoids on plants kept in continual motion to prevent concentration of a postulated hormone subject to gravitational forces lends support to a theoretical hormone control of rhizoid formation, in the megagametophytes of the Marsileaceae. The appearance of rhizoids in the usual position on the megagametophytes in flasks not shaken during the first sixteen hours following dehiscence of the sporocarps indicates that rhizoid formation is initiated during these first sixteen hours of gametophyte development.

CHEMISTRY

Chairman: FREDERIC SCHMIDT, Indiana University

KEITH WHITE, Hanover College, was elected chairman for 1963

A Quantitative Application of Thin Layer Chromatography: Assay of Tryptamine. ROBERT M. BROOKER and JOHN N. EBLE, Indiana Central College and Pitman-Moore Company.—The movement of the tryptamine front has been found to be proportional to the quantity in the range of 0.025 to 2.0 micrograms on Kieselguhr thin layer chromatography plates developed with acetone. An assay method utilizing this phenomena is described which is sensitive to 0.10 microgram of tryptamine per milliliter of plasma. It is suggested that appropriate modification of adsorbent and developing solvent should result in other uses for this convenient, rapid and simple technique.

Radical Reactions of Peroxides and Disulfides[1]

William A. Pryor, Purdue University

Using the standard techniques of polymer chemistry, (1, 2, 3) the chain transfer constant has been determined in styrene solution at 60° for the following compounds: Propyl disulfide, isopropyl disulfide, *t*-butyl disulfide, propyl peroxide, isopropyl peroxide, and *t*-butyl peroxide. The rate constant for the unimolecular, homolytic scission of the three peroxides has also been measured. Table I gives the data. Comparable data for benzoyl peroxide and disulfide are also given.

TABLE I

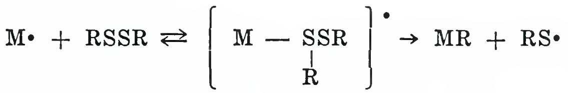
Radical reactions of peroxides and disulfides compared

	ROOR		RSSR
R=	$k_d f$	$C \times 10^4$	$C \times 10^{4}$(2)
Propyl	2.7×10^{-9} (3, 5)	8.4 (3, 5)	23.4
Isopropyl	2×10^{-9} (3, 6)	6. (3, 6)	6.60
t-Butyl	1×10^{-9} (6)	8.6 (6)	1.42
Benzoyl	2.5×10^{-6} (3)	550. (3)	107.

The unimolecular dissociation constants for all three aliphatic peroxides are similar. This reflects their similar bond energies and dissociation energies.

The chain transfer constants of the three aliphatic peroxides are also similar, and, therefore, the rate of reaction of the polystyryl radical with these three peroxides is very similar. This is unexpected in view of the known stability of *t*-butyl peroxide and the reputed explosiveness of primary and secondary peroxides. We have suggested (5) the following tentative explanation of this: The peroxides themselves are not explosives (7) at 25-60°. However, peroxides, like ethers, may be subject to peroxidation at their alpha-hydrogen atoms. Thus, isopropyl peroxide, like isopropyl ether, may be converted to an explosive by peroxidation. *t*-Butyl peroxide, then, could not form an explosive because it lacks alpha-hydrogens.

The transfer constant is very similar for each peroxide and its comparable disulfide. Since the O-O and S-S bond energies are very different (8), this suggests an addition-elimination mechanism for cleavage of the disulfides.



$$M\cdot + RSSR \rightleftarrows \left[\begin{array}{c} M - SSR \\ \qquad | \\ \qquad R \end{array} \right]^{\bullet} \rightarrow MR + RS\cdot$$

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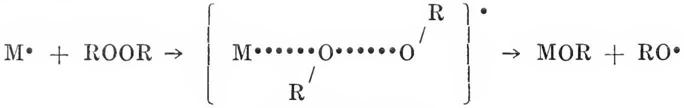
[1] This research was financed in part by Grant RG 9020 from the National Institutes of Health and Grant AT(11-1) 1169 from the United States Atomic Energy Commission. The author expresses his gratitude for this support.

Complex

The complex is similar to those proposed recently in other radical reactions (9).

Peroxides are more likely cleaved by a mechanism in which bond breaking accompanies bond making. This would be a radical displacement reaction (2).



Transition state

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The Hydrolysis of Sulfamic Acid[1]

Robert B. Fischer and Philip Haffley, Indiana University

Introduction

The slow hydrolysis of sulfamic acid in aqueous solution may be represented by the equation,

$$H\ NH_2SO_3 + H_2O \rightarrow HSO_4^- + NH_4^+$$

This reaction has proven to be useful in analytical chemistry because, when carried out in the presence of certain cations, it serves as the basis for the precipitation of insoluble sulfates from homogeneous solution (2, 4). The reaction has proven to be of special interest in this laboratory in conjunction with research on the physicochemical aspects of nucleation and crystal growth (1). In order to use the reaction for this purpose, however, it became necessary to obtain kinetic data. Only a few isolated measurements had heretofore been reported in the literature (1, 3), but these were inadequate for the present purpose.

The rate constant may be expressed by the equation,

$$\text{rate} = \frac{-d\ [HNH_2SO_3]}{dt} = k\ [HNH_2SO_3]^m$$

in which t is time, k is the rate constant and m is the order of reaction with respect to the concentration of sulfamic acid. The water molecule concentration need not appear as a variable in this equation, as it remains essentially constant in the aqueous solutions of interest in this study. Experimental measurements of rate data could be based upon determinations of sulfamic acid, or of sulfate ion, or of ammonium ion, each in the presence of the others. Sulfate determinations were selected.

Experimental Methods and Results

The reaction was run under controlled conditions, duplicate aliquots were withdrawn periodically, the reaction in each was quenched by cooling, and each was analyzed for sulfate ion by a conventional gravimetric procedure. All hydrolyses were run in the research laboratory, but all sulfate determinations were performed by students in a beginning course in quantitative analysis. The overall plan of the project was discussed with the students in advance, and the final results were subsequently discussed with and evaluated by the entire group. No student knew at the time of his analysis what the "hydrolysis history" of his sample was, nor did he even know that some one else had a duplicate of his sample.

The analytical data are summarized in table 1. Each reported value is a rounded-off arithmetic mean of triplicate determinations performed by one student. (Each student also reported his precision in terms of 50% confidence limits, but these data are not listed in table 1.) The data for the hydrolysis runs were then analyzed both by a graphical method and by a half-reaction time method, from both of which it was found that the hydrolysis reaction rate is first-order with respect to sulfamic acid concentration. The rate constants, also listed in table 1 for the seven runs, were obtained by a graphical method, and are expressed with time units as hours and with the sulfamic acid concentration in uits of "mg.SO_4 yet to form per ml. of hydrolyzing solution." These units were selected because they arose directly from the analytical data.

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[1] This work was supported in part by the U.S. Atomic Energy Commission under contract AT (11-1)-497. Publication number 1110 from the Department of Chemistry of Indiana University.

TABLE 1. ANALYTICAL DATA

Run No.	Temp. (°C.)	Initial Sulfamic Concn.	Time (Hrs.)	MG. SO_4/ML.			Rate Constant For this Run
				1	2	AVE	
1	99.5	1%	1	2.36	. . .	2.36	0.26
			2	4.27	. . .	4.27	
			4	6.32	6.49	6.41	
2	99.9	0.5%	1	0.83	0.96	0.89	0.18
			2	1.67	1.61	1.64	
			4	. . .	2.17	2.17	
3	100	1%	1¼	0.32	0.44	0.38	0.025
		(in 0.1 M.	2¼	0.68	0.75	0.72	
		NaOH)	4½	10.03+	1.05	1.02	
4	99.5	1%	1	3.53	. . .	3.53	0.51
		(in 0.1 M.	2	6.70	7.43	7.07	
		HCl)	4	8.39	8.72	8.56	
5	70	1%	1	0.13	0.13	0.13	0.012
			2	0.29	. . .	0.29	
			4	. . .	0.47	0.47	
6	80	1%	1	. . .	0.41	0.41	0.035
			2	0.82	0.73	0.77	
			3½	1.33	4.4++	1.33	
7	99.5	2%	1	6.56	0.46++	6.56	0.35
			2	10.55	10.46	10.51	
			4	. . .	14.28	14.28	

+ This result appears to contain a decimal-point error and was so considered in calculating the average.

++ These two results are clearly inconsistent with their duplicate aliquots and with the general trend of the hydrolysis, so they were discarded.

Several observations may be made from the data of table 1.

(1) The rate constant is increased considerably by the presence of excess acid (hydrochloric) and is decreased considerably by the presence of excess base (sodium hydroxide), as shown by comparison of runs 1, 3 and 4.

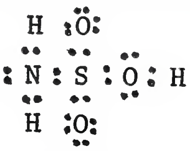
(2) The rate constant is increased somewhat by an increase in initial concentration of sulfamic acid, as shown by comparison of runs 2, 1 and 7. This fact appears at first to contradict the conclusion

that the reaction is truly first-order. However, this difference is likely again due to the acidity factor, as the hydrogen ion concentration necessarily increases as the sulfamic acid concentration is increased. The acidity should remain essentially constant during any one run, because the $H\ NH_2SO_3$ reactant and the HSO_4 product are of comparable acid strength.

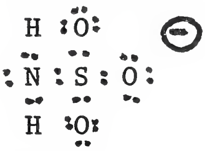
(3) The rate constant decreases considerably as the temperature is decreased, as shown by comparison of runs 1, 6 and 5. An Arrhenius plot of log k vs. 1/T for these three runs yielded a straight line, the slope of which is a measure of the activation energy.

It is of interest to speculate as to which ionic or molecular form of sulfamic acid reacts with water in the hydrolysis reaction. There are four possible species.

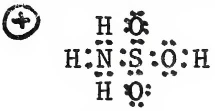
a. sulfamic acid molecule



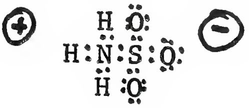
b. sulfamate ion



c. zwitter-ion form of sulfamic acid molecule



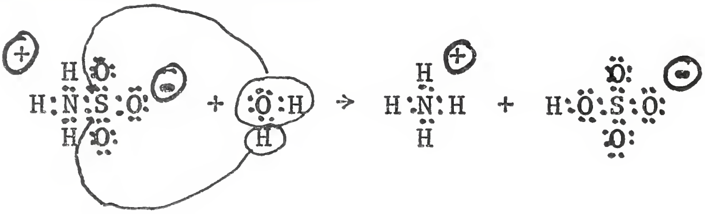
d. zwitter-ion form of sulfamate ion



For hydrolysis to sulfate and ammonia to occur, the N : S bond must be broken. Furthermore, the electrons in this bond must go with the N atom, in order to form the products which are obtained. In examining these four species, we would expect this pair of electrons to be attended most strongly to the N in the order $d>b$, $c<a$, with no evident basis for predicting a difference between b and c. This consideration at least should rule out a. as the reactive species.

At very low pH, we would expect the fully protonated species, c, to predominate, and the least protonated form, b, to be formed at very high pH. Species a. and d. are singly protonated so would be more formed at intermediate acidities. The experimental observation that the rate is enhanced at a greater acidity would seem to rule out b, at least, as the reactive species.

This leaves c and d as possibilities. Sulfamic acid is quite strong, the listed acid ionization constant being 10^2. Ths means that we would hardly expect to find the doubly protonated species, c, even in very acidic media. Therefore, it may be concluded with reasonable confidence that it is d, the zwitter-ion form of the sulfamate ion, which reacts with the water molecule during hydrolysis.



Summary

The hydrolysis reaction rate of sulfamic acid in aqueous solution to form sulfate and ammonium ions is first order with respect to sulfamic acid concentration. Excess acid (hydrochloric) markedly increases the rate, and excess base decreases it. An Arrhenius plot by log k vs.1/T yielded a straight line, the slope of which is a measure of the activation energy. It was further deduced that the form of sulfamic acid which actually reacts with the water molecule is the zwitter-ion form, $^{+}H_3N\text{-}SO_3{}^{-}$.

In addition to providing useful new data on the kinetics of the hydrolysis of sulfamic acid, this study proved to be a successful part of the laboratory work in quantitative analysis. Each student performed a gravimetric sulfate determination, merely starting with a solution unknown rather than with a conventional solid, powdered unknown. The interest and the enthusiasm of the students was enhanced by being a part of a group research problem, and the students gained some familiarity with reaction kinetics as a by-product of their quantitative work.

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The Determination of the Apparent Molal Volumes and Viscosities of Some Electrolytes in Anhydrous Ethylenediamine at 25° C.

Frederic C. Schmidt, Warren E. Hoffman[1] **and Ward B. Schaap,**
Indiana University

Introduction

Much work has been done on the physical chemical properties of solutions of electrolytes. Most of this study has been done on aqueous solutions. Attention is now turning to solutions of electrolytes in non-aqueous solvents of lower dielectric constant than water. In this work, the solvent, ethylenediamine, (D = 12.9) has been used.

All physical properties of solutions of electrolytes are modified by ion association. Through the measurement of viscosities and partial molal volumes of salts dissolved in this amine solvent we hope to gain some knowledge, along with other measured properties, of the extent of formation of ion pairs in the dilute and concentrated regions of solution. Viscosity measurements provide a moderately sensitive indication of the presence of ions other than the simple type. The viscosity of a dilute

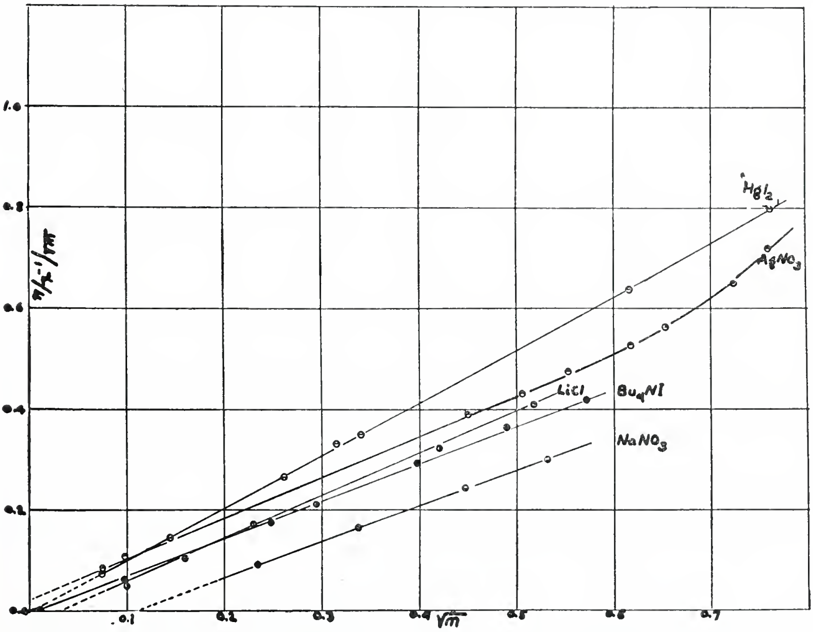

Figure 1. Graph Showing the Experimental Results of the Relationship η/η_0-1 / m½ for Various Electrolytes in Anhydrous En.

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electrolytic solution can be accurately represented in the majority of cases by the equation (1)

$\eta/\eta_0 = 1 + A\sqrt{m} + Bm$ in the more dilute regions, ie: less than 0.1m. A and B are constants. The term, $Am^{1/2}$ is due to inter-ionic forces, and can be calculated for a given solute from its charges (valency) and the mobility of its ions, giving the limiting slope. This slope can then be compared with the experimental slope by plotting $[\eta/\eta_0 - 1/\sqrt{c}]$ against the $\sqrt{c}$ as shown in Fig. 1. The B coefficient (ax is intercept) may be positive or negative in both aqueous and nonaqueous solution. So apparently besides the positive effect[1] predicted by theory there is another effect (possibly due to the solvent) which can affect the viscosity. A negative B can be regarded in a sense as an ion loosening effect on the solvent.

According to Stokes' law a particle of radius γ cm. moving through a homogenous medium of viscosity η under the influence of a force F will maintain a velocity V, given by $V = F/6\pi\eta\gamma$. When the definition of equivalent ionic conductance is introduced, this becomes

$$\Lambda^{\circ}_{i} = \frac{8.20 \times 10^{-9} Z_i}{r_i}$$

transforming:

$$r_i = \frac{8.20 \times 10^{-9} Z_i}{\Lambda^{\circ}_{i}}$$

where Z_i is the charge involved on the electrolyte ions. Thus effective ion radii can be calculated from the ion mobilities and viscosities. According to Walden's Rule the conductance—viscosity product is constant (2). It has been shown that the Λ° product varies widely from solvent to solvent. This reflects the solvation numbers and should give the extent of binding of solvent molecules by the ions involved.

Another method of estimating the specie of ions present in solution is the study of the apparent partial molal volumes exhibited by the electrolytes involved. The apparent molal volume can be calculate from the density of the solutions by the following formula.

$$\phi_v = \frac{1000}{m d d_0} (d_0 - d) \frac{M}{d}$$

where d_0 is the density of the solvent, d, the density of the solution, m the concentration in moles of electrolyte per 1000 grams of solvent and M the moleculer weight of the electrolyte involved. The exactness of the determination ϕ_v is critically dependent upon the density measurements involved. When the $(d_0 - d)$ term gets smaller and smaller the accuracy of ϕ_v gets less and less dependent.

Masson (3) found that most aqueous solutions of electrolytes follow the following empirical relationship:

$$\phi_0 = a\sqrt{m} + b$$

where a and b are constants characteristic of the electrolytes involved. The constant (a) is related to inter-ionic distances while (b) gives some insight as to the relative size of the ions involved. Redlich (4) finds that, according to the Debye-Hueckel theory, the partial molal volumes of salts in solution should vary linearly with the square-root of the concentration.

TABLE 1

Concentrations, Densities and Viscosities of Solutions of Some Electrolytes in Anhydrous Ethylenediamine at 25.000±0.005° C.

M	$\sqrt{M}$	ρ	η^{rl}	η^{sp}	$\eta^{sp}/\sqrt{M}$
I LiCl					
0.0104	0.102	0.89365	1.0056	0.0056	0.005
0.0536	0.232	0.89512	1.0399	0.0399	0.172
0.1782	0.422	0.89906	1.1345	0.1345	0.320
0.2683	0.518	0.90242	1.2141	0.2141	0.413
II $NaNO_3$					
0.0544	0.233	0.89606	1.0227	0.0227	0.097
0.1149	0.339	0.89967	1.0561	0.0561	0.166
0.1977	0.445	0.90315	1.0797	0.0797	0.240
0.2845	0.533	0.90987	1.1655	0.1655	0.311
0.0421	0.205	0.89590	1.0030	0.0030	0.015
0.2220	0.471	0.90490	1.0877	0.0877	0.186
III HgI_2					
0.0202	0.142	0.8992	1.020	0.020	0.140
0.0681	0.261	0.9152	1.070	0.670	0.260
0.1140	0.338	0.9339	1.117	0.117	0.346
0.3771	0.614	1.0231	1.380	0.0380	0.619
0.5652	0.758	1.0868	1.571	0.571	0.760
IV $AgNO_3$					
0.0056	0.075	0.89481	1.0059	0.0059	0.079
0.0100	0.100	0.89561	1.0100	0.0100	0.100
0.0300	0.173	0.89798	1.0289	0.0289	0.167
0.3025	0.550	0.93592	1.2715	0.2715	0.484
0.3799	0.616	0.94638	1.3283	0.3283	0.533
0.4227	0.650	0.95113	1.3580	0.3580	0.551
0.5234	0.723	0.96572	1.4676	0.4676	0.647
0.7237	0.850	0.99168	1.655	0.655	0.771
0.8175	0.904	1.00490	1.7893	0.7893	0.873
0.9855	0.993	1.02648	2.0602	1.0602	1.068
1.0000	1.0000	1.02755	2.0664	1.0664	1.066
V Tetra•n-Butylammonium Iodide					
0.0052	0.072	0.89397			
0.1118	0.334	0.90172	1.0735	0.0735	0.220
0.00016	0.0126	0.89322	1.0000	0.0000	0.0000
0.00998	0.0999	0.80431	1.0062	0.0062	0.062
0.02598	0.161	0.89510	1.0174	0.0174	0.108
0.0503	0.224	0.89656			
0.0563	0.237	0.89742			
0.0625	0.250	0.89784	1.0440	0.0440	0.176
0.08525	0.292	0.90061	1.0631	0.0631	0.216
0.1611	0.401	0.90480	1.1197	0.1197	0.298
0.2422	0.492	0.91076	1.1746	0.1746	0.355
0.3261	0.571	0.91668	1.2383	0.2383	0.417
2.3673	0.606	0.91939	1.2940	0.2940	0.485

TABLE 2

Apparent Molal Volumes (ϕ_v) for Various Concentrations of Several Salts In Anhydrous Ethylenediamine at 25° C.

LiCl

m	$\sqrt{m}$	ϕ_v(ml/mole)
0.0536	0.232	10.5
0.0713	0.267	9.8
0.1728	0.422	8.0
0.2683	0.518	6.2
		ϕ_v Extrapolated 13.5 ml.
$NaNO_3$		
0.0421	0.205	33.6
0.0544	0.233	33.1
0.1149	0.339	31.4
0.1977	0.445	31.1
0.2220	0.471	30.2
0.2845	0.533	30.4
		ϕ_v Extrapolated 35.5 ml.
HgI_2		
0.0202	0.142	104.8
0.0681	0.261	106.8
0.1140	0.338	92.4
0.5652	0.752	68.2
0.7537	0.869	65.4
		ϕ_v Extrapolated 112.0 ml.
$AgNO_3$		
0.0503	0.224	19.4
0.2507	0.501	18.4
0.3025	0.550	18.3
0.3799	0.616	18.3
0.4227	0.650	17.9
0.5234	0.732	17.6
0.5624	0.750	17.5
0.8175	0.904	17.2
		ϕ_v Extrapolated 20.0 ml.
Bu_4NI		
0.0625	0.250	321.7
0.0853	0.292	319.8
0.0913	0.302	319.5
0.1611	0.401	317.0
0.1785	0.423	316.5
0.3261	0.571	316.2
0.3673	0.606	315.9
		ϕ_v Extrapolated 325 ml.

Work along these lines is to be continued.

This work was carried out by aid from A.E.C. grant (AT-11-1-256).

Experimental

The ethylenediamine used was dried over calcium hydride and fractionated in an atmosphere of nitrogen until constant density (0.8935 g. ml.$^{-1}$) was obtained.

Viscosities were run in a calibrated Ostwald viscometer. Densities were made by use of a 25 milliliter picnometer. Salts were recrystallized reagent grade and dried at 150° C. to constant weight. Constant temperature bath was kept at 25.000±0.005° C.

Summary

Our determinations of the viscosities of solutions of various electrolytes in anhydrous ethylenediamine show that the relationship between $[\eta/\eta_0 - 1/\sqrt{m}]$ and $\sqrt{m}$ is linear for those electrolytes examined over the concentration as shown in Fig. 1 and Table 1. Viscosities measured also will be used to examine the validity of Waldens' Rule for non-aqueous solutions of electrolytes.

The extension of Masson's empirical rule has been extended to non-aqueous solutions and seems to be valid as shown in Table 2.

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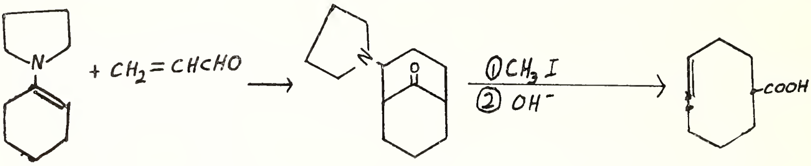
An Alternative Mechanism to the Stork Ring Enlargement[1]

A. GILBERT COOK, Valparaiso University

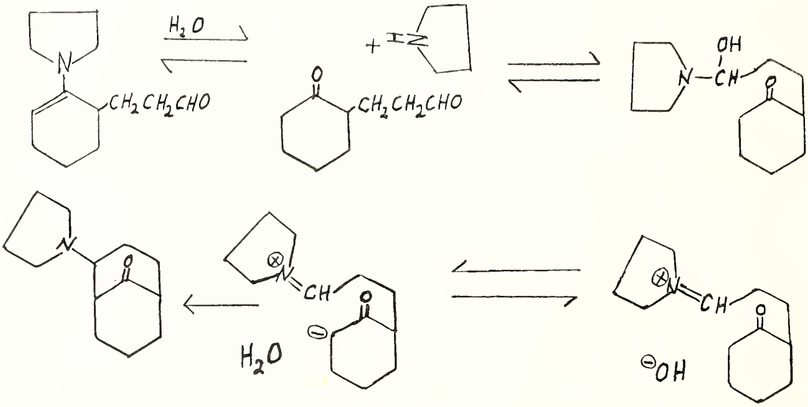
Several years ago a unique ring enlargement sequence was reported by Stork and Landesman.[1] It was found that when the pyrrolidine enamine of cyclohexanone (I) was allowed to react with acrolein, 2-N-pyrrolidylbicyclo [3.3.1] nonan-9-one (II) was formed in a 75% yield. Upon heating the methiodide of II with aqueous base, 4-cyclooctene-carboxylic acid (III) was formed. The structure of III was proven by consideration of the reactions involved in its formation along with a comparison of its hydrogenation product with an authentic sample of cyclooctanecarboxylic acid. This reaction has been found to be quite general for enamines prepared from a variety of secondary amines and substituted or unsubstituted cyclic ketones.[2] Likewise crotonaldehyde and methacrylaldehyde were successfully used in place of acrolein to produce the corresponding methyl substituted rings.



I II III

The mechanism of the initial reaction has been a subject of considerable speculation during the ensuing years. Any proposed mechanism will have to account for the apparent exchange of positions of the pyrrolidyl group and the oxygen atom.

It has been suggested by Untch[2] that, despite the attempt to make all the conditions of the reaction anhydrous, some moisture must have



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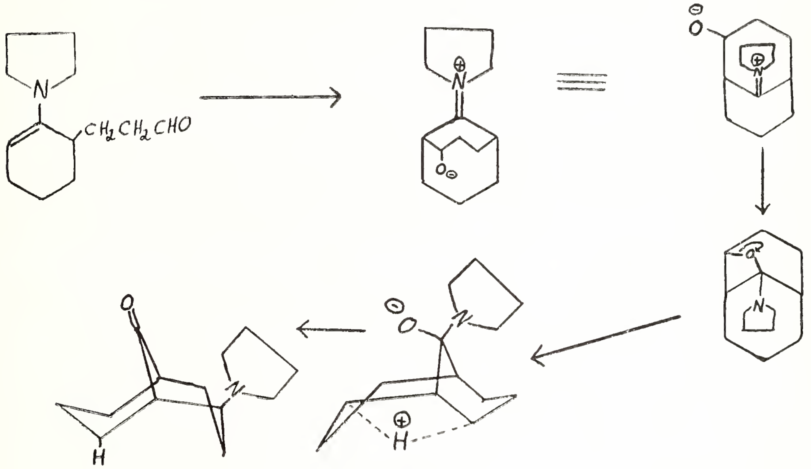
1. Work supported by the Research Corporation under a Gardner Fredrick Cottrell Grant.

crept in causing the following mechanistic sequence to take place following the initial addition of the acrolein to N-pyrrolidino-l-cyclohexene (I):

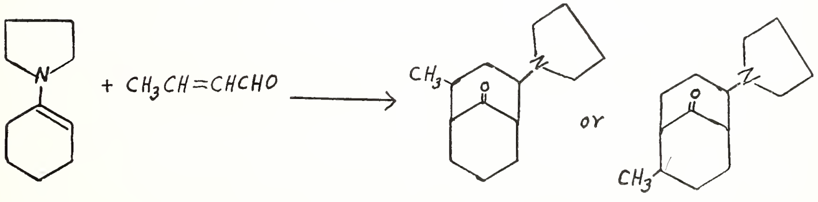
As substantiating evidence for this mechanism it was reported that when a mixture of N-pyrrolidino-l-cyclohexene (I) and N-piperidino-4-*t*-butyl-l-cyclohexene (IV) was allowed to react with acrolein, all four bicyclic products possible from such a mixture reacting according to the above mechanism (that is, with intermolecular exchange of amines) were observed. This observation was pointed to as substantiating evidence for this mechanism. However, this does not appear to be conclusive evidence for this mechanism since this same mixing can be explained merely from hydrolysis followed by reformation of the enamines possibly under the influence of the acrolein.

An alternative mechanism for this reaction involving a non-classical carbonium ion (VI)[3,4] is shown in the following sequence:



VI

In the reactions of crotonaldehyde or methacrylaldehyde the position of the methyl groups were assigned on the basis of I. R. analysis and analogy alone.[2] Therefore, they may be equally well assigned to other positions on the ring. The same uncertainty is present with the question as to which ring the pyrrolidyl group is attached to. For example, when



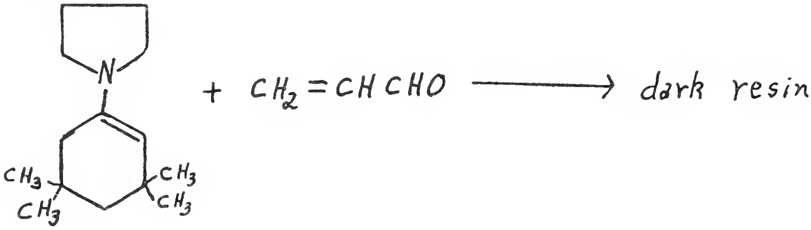
I

V

crotonaldehyde is allowed to react with N-pyrrolidino-1-cyclohexene (I), the bicyclic product, V, is produced. But the relative positions of the pyrrolidyl and methyl groups has not been unequivocally proven.[2] The unequivocal locating of these groups on the ring would certainly disprove one of the two mechanisms.

In the second alternative mechanism, if the 3 and 5 positions of the original cyclohexanone were blocked the reaction could not go to completion. With this in mind N-pyrrolidyl-3,3,5,5-tetramethyl-1-cyclohexene (VII) was synthesized in the usual manner starting with 3,3,5,5-tetramethyl-1-cyclohexene[5] and pyrrolidine in a 65% yield. The substitution of methyl groups at these fairly remote positions should not greatly influence the course of the reaction if the first proposed mechanism is in effect. This statement is further reinforced by the fact that N-pyrrolidyl-2-methyl-1-cyclohexene (in which the methyl group is in closer proximity to the reaction site) undergoes the normal reaction to give the usual bicyclic product.[2]

When N-pyrrolidyl-3,3,5,5-tetramethyl-1-cyclohexene (VII) was allowed to react with acrolein in dioxane solvent under the usual conditions, only a dark, undistillable resin remained upon removal of the solvent. Although this is not conclusive proof of the second alternative mechanism, it seems to give a strong indication that this may be the true reaction pathway.



VII

N-Pyrrolidyl-3,3,5,5-tetramethyl-1-cyclohexene. A stirred solution of 300 ml. of dry benzene, 25.1 ml. (0.30 mole) of pyrrolidine and 22.9 gms. (0.15 mole) of 3,3,5,5-tetramethylcyclohexane along with a catalytic amount of *p*-toluenesulfonic acid was refluxed under nitrogen in a one-liter flask equipped with a Dean-Stark trap for 18 hours. The solvent was removed and the residual oil was distilled through a good column. A total of 19.3 gms. (62%) of a colorless liquid product was obtained, b.p. 70° (0.2 mm.) n_D^{24} 1.4998. Anal. Calcd. for $C_{14}H_{25}N$: C, 81.09; H, 12.15; N, 6.76.

Found: C, 81.22; H, 12.09; N, 6.88.

Reaction of N-Pyrrolidyl-3,3,5,5-tetramethyl-1-cyclohexene with Acrolein. To a stirred, ice-cold solution of 3.36 gms. (0.06 mole) of acrolein in 50 ml. of dioxane was added all at once 12.22 gms. (0.06 mole) of *N*-pyrrolidyl-3,3,5,5-tetramethyl-1-cyclohexene in 20 ml. of dioxane. The reaction mixture was stirred under nitrogen at room temperature for 17 hours. The solvent was removed and only a dark, undistillable resin remained.

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Studies on the Wet-belly Disease of the Mink

William L. Leoschke, Valparaiso University

The wet-belly disease of the mink is characterized by an accumulation of urine in the fur adjacent to the urinary orifice (Fig. 1). De-

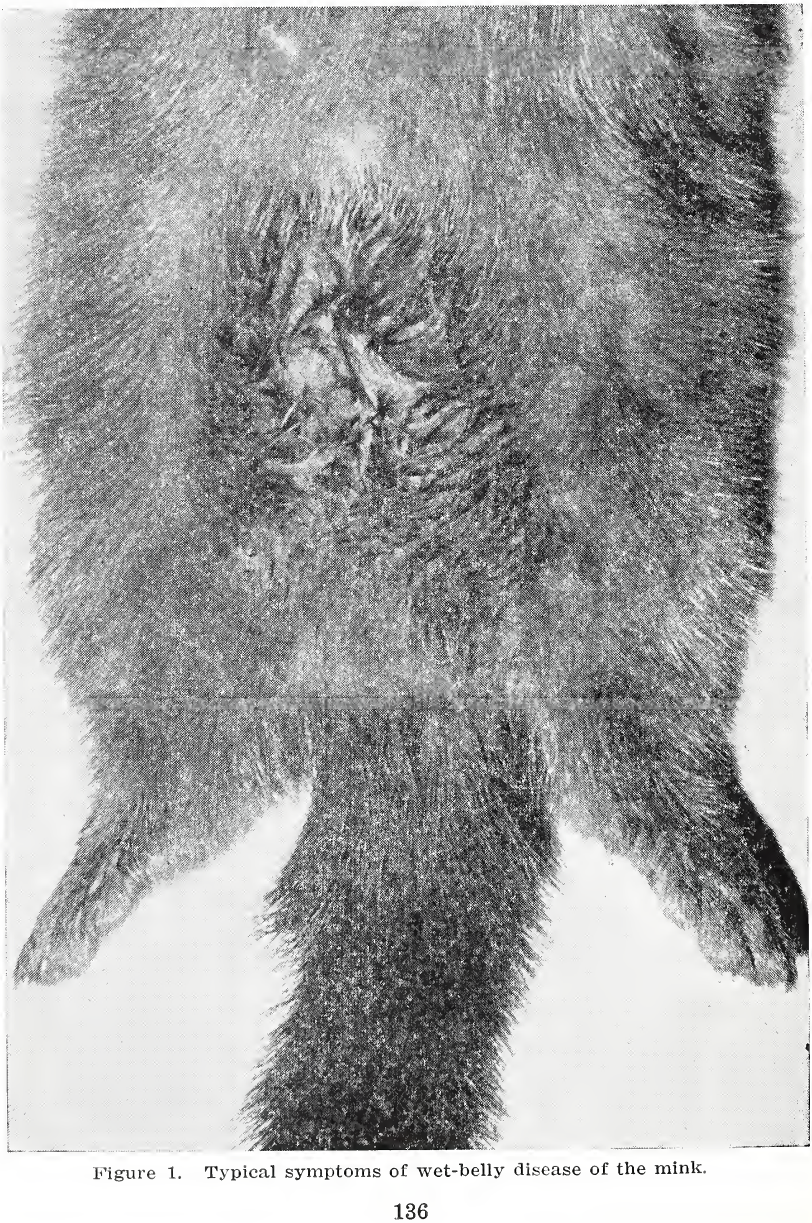

Figure 1. Typical symptoms of wet-belly disease of the mink.

composition of the urine results in permanent damage to the pelt. Nutritional studies have indicated a correlation between the incidence of the disease and ranch diets containing high levels of fat (2,3) or an imbalance of calcium and phosphorus (3,4). Bacterial infection may also be a contributing factor in this complex malady (1).

The wet-belly disease is primarily limited to male kits in the late fall months or during the breeding season in March. These ranch observations led to a study on the role of male hormones (methyl testosterone) in the wet-belly disease of the mink. This work was supported in part by a research grant from the Mink Farmers Research Foundation, Milwaukee, Wisconsin.

Experimental

The 60 day experimental feeding program was initiated in late September 1960. A group of 80 pastel kits were ramdomly assigned to 3 groups consisting of 10 males and 10 females for each experimental group (A and B) and 20 males and 20 females for the control group (C). All animals received a practical ranch diet consisting of cereal mix, 15%; lactalbumin cheese, 6%; cooked eggs, 9%; chicken heads, 37%; chicken heads and entrails, 13%; beef rumen, 9%; and ocean fish, 11%. The control mink received this ranch diet supplemented with 1% corn oil. The experimental animals received this same ranch diet and a 1% corn oil supplement providing either 0.4 mg (Group A) or 4.0 mg (Group B) of methyl testosterone per pound of wet feed. With the supplemental corn oil the control and experimental animals received a diet containing about 21.7% fat on a dehydrated basis.

Results and Discussion

Observations of the mink for the characteristic symptoms of wet-belly diseases were made once a week during October and November. By mid-November a significant increase in the incidence and severity of the wet-belly disease was noted in the male kits of the hormone supplemented groups (Table 1). No wet-belly disease symptoms were noted

TABLE 1

Dietary Methyltestosterone Supplementation and Incidence and Severity of Wet-belly Disease.

	Wet-belly Disease	
Grouping[1]	Incidence[2]	Severity[3]
C Control	5%	1
A 0.4 mg	20%	3
B 4.0 mg	40%	6

[1] mg methyltestosterone per lb. wet feed.

[2] Incidence on Nov. 19, 1960, point of highest wet-belly disease incidence.

[3] Arbitrary classification with the number representing total points per 10 animals: 1—slight case; 2—good case; 3—severe case and 4—very severe case. Figure 1 is representative of a 2 rating.

in the female kits in either the control or experimental groups. Cessation of the hormone treatment resulted in an immediate drop in the incidence and severity of the external manifestations of the disease.

Examination of the kits at pelting in late November revealed the presence of yellow stained fur and an area of blackened leather about the urinary orifice of the wet-belly diseased animals. The fur quality of the experimental and control animals was similar. Significant clitoris development was noted in the female kits receiving methyl testosterone. It is interesting to note that the rancher observed a direct correlation between the level of male hormone supplementation and the difficulty of removing the pelts from the experimental animals. Pelts from the female kits receiving the male hormone were about as difficult to remove as normal male pelts. Pelts from the male kits treated with methyl testosterone were almost impossible to remove without tearing.

It is apparent from the data presented that the presence of a male hormone (methyl testosterone) in the diet of ranch mink resulted in a significant increase in the incidence and severity of wet-belly disease. It is difficult to pin-point the exact role of male hormones in the production of this disease. It is possible that the male hormone may increase the kidney excretion of those chemicals responsible for the characteristic symptoms of the wet-belly disease of mink. This may be done by a direct action on kidney function or by influencing the levels of certain chemicals in the blood. It has been well documented that male hormones raise blood levels of the beta-lipoproteins (containing high levels of cholesterol and triglycerides) while female hormones raise the level of alpha-lipoproteins (containing high levels of phospholipids and protein). Reference has already been made to the correlation between dietary fat levels and the incidence of wet-belly disease of the mink.

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ENTOMOLOGY

Chairman: B. Elwood Montgomery, Purdue University
George E. Marshall, Experimental Horticulture Orchard, Mitchell,
was elected chairman for 1963

The Ecology of Winter Stoneflies in the Columbus, Indiana Area. Robert G. Chappell and Leland Chandler, Columbus High School and Purdue University.—Collections of winter stoneflies were made weekly at six stream stations in the vicinity of Columbus. The period of adult emergence ranged from January 27, 1962 to April 14, 1962. Five species of stoneflies were collected. Several types of analyses were used to demonstrate the ecological significance of these stonefly populations in stream classification.

Interbreeding between Floridan and Cuban *Copelatus* (Coleoptera: Dytiscidae). Frank N. Young, Indiana University.—In Florida and the southeastern United States the *Copelatus caelatipennis* Aubé complex is represented by a distinct population which shows little variation over a considerable range. The Cuban population, *angustatus* Chevrolat, is similarly uniform, but with several characters contrasting sharply with those of the Floridan form. Collections made over a period of many years by various collectors showed no indication that these two populations overlapped. They were consequently considered to be distinct species or insular subspecies on the basis of morphological similarity.

Recent collections, using ultraviolet or blacklight traps, made by the Florida Department of Agriculture, Division of Plant Industry, however, produced some very interesting specimens which must be the result of interbreeding of the Cuban and the Floridan form. Specimens from Miami and West Palm Beach, Florida, examined by the writer, show various combinations of the characters of the supposed parents. Some resemble *angustatus* very closely except that they are more finely punctate and larger and more robust than any specimens seen from the West Indies. Other specimens from the same collections are apparently identical with the normal Floridan form. Between these extremes are specimens showing mixtures of characteristics and some show characters not seen in either of the supposed parent stocks. The lack of uniformity in the variation suggests that the Cuban and Floridan populations have been separated for a considerable time and have only recently been reunited either by natural or artificial introduction of the Cuban form. The larger size of individuals also suggests that heterosis may be involved.

The mortality of *Ceratina metallica* Smith during hibernation. Paul F. Hardwick and Leland Chandler, Bedford High School and Purdue University.—Stems containing hibernating individuals or aggregations of *Ceratina metallica* were collected from November, 1961 through April, 1962. The number of living and dead individuals were recorded and the relationship between mortality and seasonal temperatures was studied. Several factors relating to population density and burrow characteristics were found to be of importance in determining survival.

Effect of Infestation of the Angoumois Grain Moth on the Germination and Vigor of Corn. RAY T. EVERLY[1], PENNY SANDBERG and BONNIE WEAVER[2].—Tests were made to study the effect of the infestation of the Angoumois grain moth on the germination of corn and the vigor of the resulting seedlings. The treatments included two kinds of corn, popcorn and dent corn, infested and non-infested seeds of each and treatments with a fungicide as well as untreated seed. Two methods of germination were used. These were laboratory tests using modified half-pint ice cream cartons with moist filter paper and greenhouse tests in flats of soil. The statistical design in both methods was an 8 x 8 latin-square. The results indicated that infestation by the larvae of the Angoumois grain moth had a greater effect in reducing the germination and vigor of popcorn than dent, although the reductions in the dent corn were significant, particularly when grown in soil. The use of a seed fungicide, Arasan, had definite value in the soil tests.

Occurrence of *Aedes excrucians* (Walker) in Indiana. R. E. SIVERLY, Ball State College.—*Aedes excrucians* (Walker) belongs to a group of approximately six species of mosquitoes which characteristically have broad, white bands at the bases of the tarsal segments but lack white bands on the proboscis. The identification of these species is not clear-cut in any stage. Its relative size and the shape of the tarsal claws separate *Aedes excrucians* from other members of the *Aedes stimulans* group. *Aedes stimulans* was first reported as occurring in Indiana by the author at the academy meetings in 1959.

Aedes excrucians adult females were taken from a densely wooded area near Muncie in June, 1962. To the author's knowledge, there are no previously published accounts of the occurrence of this mosquito in Indiana.

Although the species is univoltine, females are vicious biters and tend to remain in a given area for several weeks. This may be an important pest of man and livestock in wooded areas in Indiana during late spring and summer.

Preliminary Studies on the Ovicidal Effects of Wheat Flour-Buttermilk Combination on the Eggs of *Panonychus ulmi* (Kock) in Southern Indiana. A. V. GHATE and G. E. MARSHALL, Purdue University.—Soon after it was found that the wheat flour-buttermilk combination was effective in controlling the mobile forms of European red mite, *Panonychus ulmi* (Koch), and two-spotted spider mite, *Tetranychus telarius* (L.), attacking apples in Southern Indiana, preliminary studies were conducted to ascertain the effects of this formulation on the eggs

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1. Entomology Department, Purdue University, Lafayette, Indiana.
2. Participants in the National Science Foundation Summer Science Program for High Ability Secondary School Students from Lagro, Indiana and Brazil, Indiana high schools. respectively.

of the European red mite. The studies indicate that in addition to the effect of flour and buttermilk on the mobile forms of mites, a sufficiently large number of eggs are also killed, thus constituting a valuable aid in mite control. Counts after one week showed that 51 to 62 percent of the eggs hatched on leaves treated at different spray intervals as compared to 83 to 91 percent hatched in case of check. The nature of the action of this combination on mite eggs is not yet fully understood.

Hessian Fly and Wheat Jointworm Infestations in Indiana in 1962. J. H. HATCHETT, Agr. Res. Service, U.S.D.A.—Wheat samples collected by personnel from the Indiana Seed Certification Service, and the laboratory staff of the U. S. Department of Agriculture showed that Hessian fly infestations in 1962 had increased, compared to the previous year. Seventy-five samples from 36 counties ranged from 0 to 45 per cent infestation and had an average infestation of 10 per cent for the susceptible varieties—Knox, LaPorte and Vermillion. Resistant varieties ranged from 0 to 9.4 per cent and averaged 3.0 per cent infestation. Although in general the infestations were only low to moderate, 88 per cent of the samples collected from the susceptible varieties were infested which indicated the uniformity of existing populations. Fifty per cent of the samples collected from fields of the resistant varieties—Monon, Redcoat and Dual—were infested, indicating either a build-up of Race B, impure seed sources due to outcrossing with susceptible varieties or improper handling of seed.

In conjunction with the Hessian fly survey, wheat samples were also examined for wheat jointworm infestations. Fifty-six samples from 31 counties showed an average infestation of 7.5 per cent which was an increase over the 1960 (5 per cent) and 1961 (1 per cent) seasons. Although the average infestation is not considered to be of high incidence, there were high to moderate infestations in the following counties: Henry (88 per cent), Rush (52 per cent), and Montgomery (39 and 24 per cent).

Insects and Other Arthropods of Economic Importance in Indiana in 1962

JOHN V. OSMUN, Purdue University[1]

Customarily, this annual report of insect occurrence is prefaced by a cursory summary of the weather as a principal influencing factor in both insect abundance and host development. The conditions for 1962 merit more detailed consideration. April was below normal in precipitation and the first three weeks below average in temperature. Commencing with the last week in April, and continuing through the first week in June (7 weeks), maximum temperatures averaged 6 degrees F. above normal; similarly, minimum temperatures averaged 10 degrees above normal. May was nearly the hottest one on record with mid-May temperatures reaching 90 degrees F. in all areas of the state. These temperatures were accompanied by adequate moisture, the state being blanketed by a tropical airmass with associated cloudiness, high humidity, and frequent showers. The remainder of the summer was characterized by normal to below normal maximum temperatures, about average minimum temperatures, and normal rainfall. Many host plants and spring planted crops responded dramatically to the early, favorable weather to the extent that growth was two weeks ahead of normal. The resulting ecological conditions were reflected in the early appearance of large numbers of some insect species and conditions favorable for supporting high populations of some destructive insects, especially among the chewing groups. Insects favored by a long season of warmth and adequate moisture responded accordingly in 1962.

Field and Crop Insects

Armyworm (*Pseudaletia unipuncta* (Haw.)) moths were low in number during the first flight, but following favorable growing conditions for first generation larvae, the second flight was very large.

A billbug (*Sphenophorus callosa* (Olivier)) continued to cause serious damage to corn plants in Montgomery County. The area is a muck soil and is heavily infested with chufa or yellow nutgrass (*Cyperus esculentus* L.), the preferred host plant of the billbug. Reduction of stand from billbug feeding was about 25 percent, while 85 percent of the remaining corn plants showed typical leaf injury. Reports from St. Joseph and Decatur counties indicated an abundance of the insect in those areas. Two other species (*S. zede* (Walsh) and *S. recta* (Say)) have also been collected and identified.

Blister beetles (*Epicauta* spp.) were again common on many crops, especially on tomatoes and potatoes in localized areas. In alfalfa fields, a pronounced increase was noted. This year's population, coupled with a high grasshopper year, indicates a potential for a large population in 1963.

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[1] Information for this summary has been provided by: W. L. Butts, H. O. Deay, R. C. Dobson, R. E. Dolphin, R. T. Everly, R. L. Giese, G. E. Gould, D. W. Hamilton, G. E. Marshall, D. L. Schuder, M. C. Wilson.

Cereal leaf beetle (*Oulema melanopa* (L.)), also called the grain leaf beetle, was reported by the State Entomologist for the first time in St. Joseph and LaPorte counties in August 1962. This is a European pest which attacks small grains and most species of grasses and may be a serious threat to Indiana agriculture. Its first occurrence in these two counties and the adjacent area in Michigan suggests that the pest may have entered the United States by way of the St. Lawrence Seaway.

Common stalk borer (*Papaipema nebris* (Guen.)) returned to a low population level this year and has been of little economic importance.

Corn earworm (*Heliothis zea* (Boddie)) moths and larvae were generally scarce until late August as substantiated by both observation and light trap catches. A pronounced rise in late moth abundance suggested the possibility of an unusually heavy fall infestation. Cold, rainy weather in early September reduced the seriousness of this problem except in corn that was silking at that time. Losses were about double those of 1961 with the greatest increase in the south.

Corn leaf aphid (*Rhopalosiphum maidis* (Fitch)) again showed an increase over the preceding year. Average infestations for the year showed a 4 percent increase with the percent loss increasing from 3.0 in 1961 to 4.1 in 1962. Increases were apparent in the following regions of the state: NNW, NNC, SC, and SSW; decreases were significant in the SE, SSC, and SSE.

European corn borer (*Ostrinia nubilalis* (Hbn.)) showed a general increase in borers per 100 plants except in the far south where a decrease occurred. A localized, heavy infestation and moth flight occurred in Jasper County both in the first and second generation. A light trap operated at this location caught an average of 65 moths per night, May 28-June 4; 100 per night, June 5-11; 50 per night, July 10-17; and 100 per night, July 18-31. The fall corn survey in this same area revealed 52.7 percent infestation with an average of 87.3 borers per 100 stalks. G. E. Gould reported that potatoes grown in the region were 100 percent infested with the corn borer. The overall state average was 27.0 percent infestation and 32.0 borers per 100 plants.

Southern corn rootworm (*Diabrotica undecimpunctata howardi* (Barber)) was present on corn, while populations of the adult beetles on cucurbit and other crops were somewhat lower than usual.

Northern corn rootworm (*Diabrotica longicornis* (Say)) is becoming more of a problem, especially where farmers are following a program of continuous corn. Losses in general were negligible in 1962, as growing conditions were good. Beetles feeding on corn silks were reported from a few counties.

The striped cucumber beetle (*Acalymma vittata* (Fab.)) appeared the middle of May, about two weeks earlier than usual. On the whole, wilt was much more prevalent than in former years. The beetles migrated into commercial fields and home gardens in small numbers over a period of several weeks. As a consequence, fewer areas were treated with sufficient insecticide to check the beetles and thus the bacterial wilt which they spread. A related species, *A. gouldi* (Barber), was described from specimens collected in Indiana in 1942 and had not been collected since. During the summer and fall of 1962, numerous specimens were found on wild cucumber, squash, melons and cucumbers.

Cutworms were of minor importance during 1962 and few reports were received. Some losses to corn were caused by the black cutworm (*Agrotis ipsilon* (Hufnagel)) early in the season. Meadow mint was damaged early by several species of cutworms.

Fall armyworm (*Laphygma frugipenda* (J. E. Smith)) occurred in low populations in 1962.

The fruit fly (*Drosophila melanogaster* (Meig.)) continues to be the major insect problem confronting the canning industry. Even though some fields had been treated with an insecticide on a 3-day schedule, fly populations and egg deposition in baits were quite high in late September.

Grasshopper (*Melanoplus* spp.) populations again increased over the preceding year. Damaging infestations occurred in localized areas throughout the southern three-fourths of the state. The dominant species were *M. femurrubrum* (DeG.) and *M. differentialis* (Thomas). In Decatur County, an infestation in one field of soybeans averaged 40 grasshoppers per square foot.

Hessian fly (*Phytophaga destructor* (Say)) infestations increased over 1961. Seventy-five samples from 36 counties ranged from 0 to 45 percent infestation, and averaged 10 percent for susceptible varieties. Resistant varieties ranged from 0 to 9.4 percent, and averaged 3 percent.

Tobacco hornworm (*Protoparce sexta* (Johan.)) caused little damage to tomatoes. Fewer larvae were observed on plants and moth flight numbers were down.

Japanese beetle (*Popillia japonica* (Newman)) occurs in at least 52 localities in the state. In September of 1962, the state was placed under a federal quarantine which prohibits shipment of certain plants and plant products to states to the north and west. One infestation in Newton and Benton counties occurs in a rural area where the adult beetles feed on the foliage of smartweed and soybeans and to a lesser extent on the silks of corn. Although the infested area on the Indiana side of the state line is some 180,000 acres, heavy populations occur only over 2000 acres. Losses to soybeans from beetles feeding on the foliage has run as high as 33 percent in some fields. Beetle feeding on corn silks in one heavily infested field reduced pollination on some ears to the extent of yield reductions of 25 percent.

Meadow spittlebug (*Philaenus spumarius* (Linnaeus)) was again a serious insect problem on alfalfa and clover in Indiana. It was most abundant in the southeastern counties. Each year infestations become of greater significance in the southwestern part of the state from Terre Haute to Evansville. They were higher in 1962 in this area than in previous years.

The potato leafhopper (*Empoasca fabae* (Harr.)) continues to be one of the major insect pests in the state, as it is destructive to potatoes, beans, alfalfa, and clover. On the latter two, there was considerable yellowing and stunting in July and August. Plantings of Purdue's new alfalfa variety, Culver, which was developed for insect resistance, showed very little damage from either potato leafhoppers or spittlebugs in comparison with other varieties.

Spotted alfalfa aphid (*Therioaphis maculata* (Buckton)), for the sixth consecutive year, was not successful in surviving the winter in Indiana. Infestations were not found in the state until mid-September when the insect was collected in small numbers in Harrison, Floyd and Clark counties. Winged adults were taken in the latter two areas.

Wheat jointworm (*Harmolita tritici* (Fitch)) infestations, based on fifty-six samples from 31 counties, showed an average infestation of 7.5 percent, which was an increase over 1961. Infestations ranged from 0 to 88 percent of the stems infested per field sample.

Wireworms occurred as damaging populations in localized areas. In Montgomery County, a high population caused serious losses in a field of mixed corn and grain sorghum.

Fruit Insects

Apple maggot (*Rhagoletis pomonella* (Walsh)) infested almost 100 percent of the fruit in small unsprayed orchards in northern Indiana. Commercial growers, adjacent to such locations, experienced difficulty in preventing oviposition in their apples.

The codling moth (*Carpocapsa pomonella* (L.)) was expected to cause difficulties this year due to last season's build-up. The potential was there and persistent efforts were necessary to contain the pest. Larvae continued to hatch well into October.

Grape cane gall maker (*Ampeloglypter sesostris* (Le C.)) was almost absent after three years of heavy attack in some vineyards.

European red mite (*Panonychus ulmi* (Koch)) populations started building up before petal fall and continued to be persistent and, in many instances, high through August 10. This species has become resistant to most of the miticides labelled for use during the post-bloom period.

Four-spotted spider mite (*Tetranychus canadensis* (McGregor)) was not found in Indiana orchards.

Two-spotted spider mite (*T. telarius* (L.)) was prevalent in many orchards from mid-June into late August, but was not as severe in September as it was in 1961. The species is highly resistant to most miticides labelled for their control.

Red-banded leaf roller (*Argyrotaenia velutinana* (Walker)) was again low in numbers, although considerable damage occurred in October to apples in common storage.

Rosy apple aphid (*Anuraphis rosea* (Baker)) appeared in average or below average numbers.

A whitefly (not identified) was serious on strawberries and grapes in southern Indiana.

Woolly apple aphid (*Eriosoma lanigerum* (Hausmann)) was exceptionally numerous in a few isolated orchards in southern Indiana.

Livestock Insects

Cattle grubs (*Hypodermia bovis* (Linnaeus) and *Hypodermia lineatum* (de Villers)) continued to be serious pests of shipped-in feeder animals and were moderate pests of locally grown animals.

Face fly (*Musca autumnalis* (DeG.)) was present over most of the state again this year. Populations remained fairly low throughout the west and central areas until late summer when abundant rains and warm weather resulted in environmental conditions suitable for a build-up. The eastern quarter of the state had high populations throughout the summer since rainfall conditions were more conducive to large populations here than over the rest of the state.

Horn fly (*Haematobia irritans* (L.)) was present in large numbers on untreated cattle during the summer throughout the northern half of the state after a dry period in the spring had prevented an early build-up. Areas with normal rainfall had many flies even early in the season. Populations this year showed a slow build-up and only one peak (late in the summer), compared to a normal early peak, a reduction during midsummer, and another peak in the fall.

Horse flies (*Tabanus atratus* (Fab.) and *T. sulcifrons* (Marquart)) were at the lowest level of the past three years.

House fly (*Musca domestica* (L.)) built up to high populations early in the summer due to very warm conditions in May. This species was extremely abundant around barns where press of spring planting prevented carrying out proper sanitation practices. The populations dwindled during the summer to normal levels and remained normal for the remainder of the season.

Stable fly (*Stomoxys calcitrans* (L.)) was present in normal populations throughout the year, becoming a pest locally where bedding was not removed frequently.

Pests of Man and Households

The larger yellow ant (*Acanthomyops interjectus* (Mayr)) has caused great concern among homeowners during September and early October. Its rather massive swarming flights have been mistaken for the activities of termites and frequent inquiries have been received.

The Asiatic oak weevil (*Cyrtepistomus castaneus* (Roelofs)) was taken in Indiana for the first time. In Jennings and Jackson counties, great numbers of this weevil were found invading houses. It was also taken in Harrison County in sweep samples from alfalfa.

Cat flea (*Ctenocephalides felis* (Bouché)), as based upon requests received, was a considerable pest in homes during the latter part of the summer.

Elm leaf beetle (*Galerucella xanthomelaena* (Müeller)) adults have been the subject of complaints since mid-June with many beetles entering houses even from the first generation population.

The German cockroach (*Blattella germanica* (Linnaeus)) continues to cause trouble throughout the state, and the presence of several chlordane-resistant strains have been definitely established.

House cricket (*Acheta domesticus* (L.)) occurred as a localized but very severe population and invaded the town of Waverly, Morgan County, during early June. Extensive spraying of yards and a nearby dump finally gave control.

Mosquito populations have caused an increasing interest in various parts of the state concerning community control operations and, in most cases, there has been little evidence of sound planning for such operations.

Picnic beetles (*Glischrochilus* (spp.)) were of considerable nuisance importance. The problems caused by these insects, with respect to disrupting picnics and other outdoor activities, have increased during the year, although complaints during late August and September were not so numerous as expected.

The straw itch mite (*Pyemotes ventricosus* (Newport)) was abundant and severe in straw throughout the state in the fall. Many complaints were received of attacks on man and fumigation of some stored straw was necessary.

Subterranean termites (*Reticulitermes* (spp.)) were of considerable importance during the spring swarming season with many requests for information on control. There is also evidence that preventive soil treatments for new construction are becoming better understood and accepted.

Ticks, as based on the number of inquiries received concerning tick control, have been unusually low this year.

Tree, Shrub and Forest Insects

Bagworm (*Thyridopteryx ephemeraeformis* (Haworth)) was important on both evergreens and deciduous trees, many evergreens being killed by defoliation in August.

Birch leaf miner (*Fenusa pusilla* (Lepeletier)) commonly damaged white birch foliage in ornamental plantings at Plymouth.

Catalpa sphinx (*Ceratomia catalpae* (Boisduval)) caused almost complete defoliation of catalpa in many areas in north central Indiana.

The columbian timber beetle (*Corthylus columbianus* (Hopk.)) is at the lowest population density in many areas of Indiana since 1954.

Cottony maple scale (*Pulvinaria innumerabilis* (Rathv.)) populations were lower than for the past several years in northern Indiana. Hatching of the eggs occurred early in June because of unseasonably warm weather.

Eastern tent caterpillar (*Malacosoma americanum* (Fabricius)) formed nests in flowering peach trees and wild cherry trees in late April and early May in southern Indiana. Population levels were about normal.

Elm leaf beetle (*Galerucella xanthomelaena* (Müller)) was extremely abundant on Chinese elm in the greater Lafayette area. Many complaints of damage and requests for control recommendations were received during the month of August.

The European pine sawfly (*Neodiprion sertifer* (Geof.)) continued to be an important pest of pine plantations and was found in Perry County for the first time.

European pine shoot moth (*Rhyacionia bouliana* (Schiffermüller)) began emerging the first week of June in northern Indiana, about 10 days earlier than normal. For the first time, it was found in Perry County.

Fall webworm (*Hyphantria cunea* (Drury)) was unusually abundant throughout the northern tier of counties where many trees were defoliated.

Fletcher's scale (*Lecanium fletcheri* (Cockerell)), a severe pest of yews, arbor vitae and juniper, was more destructive than normal in many areas of the state.

Hackberry lace bug (*Corythucha celtidis* (O. and D.)) populations were low this year.

The holly leaf miner (*Phytomyza ilicis* (Curtis)), a frequent pest in the southernmost counties of the state, was discovered infesting hollies in Vigo County for the first time.

Honeylocust gall mite (*Eotetranychus multidigitula* (Garman)) was common on thornless honeylocust trees at LaPorte early in July.

A juniper tip midge (*Oligotrophus* (Sp.)) occurred in large numbers on cannaert junipers throughout the state.

Leaf roller (*Tortrix pallorana* (Rub.)) larvae of the first generation continue to be important in two and three year old pine plantations. Parasite population appears to be building up and may help in keeping damage below economic levels in future years.

Locust leafminer (*Xenochalepus dorsalis* (Thunberg)) damaged black locust foliage in several areas of the state. Mining of the leaflets caused the foilage to turn brown as if scorched by fire.

Maple bladder gall mite (*Vasates quadripedes* (Shimer)) was again common on silver maples throughout the state.

Maple petiole borer (*Caulocampus acericaulis* (MacGillivray)) caused concern in mid-May by defoliating hard maples in several areas of the state.

The mimosa webworm (*Homadaula albizziae* (Clarke)) continues to spread northward in the state. The infestations, particularly those of the first generation, appeared less devastating, although fully as numerous as last year.

Nantucket pine moth (*Rhyacionia frustrana* (Comstock)) continues to damage terminals of pine trees in southern Indiana, especially in new plantings. Virginia and Jack pines are the most susceptible pine species.

Oak kermes (*Kermes* (spp.)) was less troublesome on bur and white oaks than in previous years.

Oak skeletonizer (*Bucculatrix ainsliella* (Murtf.)) populations fell below economic levels in 1962.

The oak succulent gall (*Andricus palustris* (O.S.)) was commonly found on pin oak; many complaints were received.

The Pales weevil (*Hylobius pales* (Herbst)), often a severe pest of young pine trees, was discovered in Brown County attacking Scotch pine. This is the first time that the insect has been reported from the state since 1916. Damage was negligible.

A pine weevil (*Pissodes approximatus* (Hopk.)) was discovered killing two and three year old pine transplants in Jefferson County. The larvae feed beneath the bark above the soil line and girdle the plant. Pupation occurs in June within a typical chip cocoon.

The red-headed pine sawfly (*Neodiprion lecontei* (Fitch)), an occasionally destructive defoliator of pine, was found in Franklin and Perry counties in June.

Smaller European elm bark beetle (*Scolytus multistriatus* (Marsh)), the vector of Dutch elm disease, continues to be important in the northern portion of the state, where the disease is common.

Sod webworms (*Crambus* (spp.)) were much more abundant than for several years, doing extensive damage to lawns and turf throughout the state. Economically, it was one of the most important insects of 1962.

Spruce spider mite (*Oligonychus ununguis* (Jacot)) was abundant on evergreens in late June in many areas of the state.

The walking stick (*Diapheromera femorata* (Say)) was again represented by a high population density in Stark County where it was feeding on black oak.

Walnut caterpillar (*Datana integerrima* (G. and R.)) populations were lower than in 1961; fewer walnut trees were defoliated, and few complaints of damage were received. One contributing factor appeared to be lack of adequate food supply due to an early leaf disease.

The Zimmerman pine month (*Dioryctria zimmermani* (Grote)) continues to damage pine trees in the northern half of the state. It was reported from Boone County for the first time. Infestations in poorly managed stands averages 85 percent.

It is customary, in this annual report, to list the ten most important insects and related Arthropods in Indiana for the year. Judgment is always difficult and ranking is by composite opinion rather than from quantitative survey data. A large number of insects were present in significant numbers in 1962 and considerable expenditures were made to contain others. Furthermore, it could be said that serious difficulties were not experienced from any species, due principally to a favorable growing season in which plants supported large populations without apparent severe depredation. There was, therefore, no agreement among the reporting staff as to those belonging to the first ten.

Studies of the Eggs of Odonata[1, 2]

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Published information on the number of eggs produced by Odonata is scarce. Kormondy (1958) noted that 1060 naiads hatched from a single strand of eggs of *Tetragoneuria cynosura* (Say), but added, "It is impossible, however, to compare the number of eggs they produce with the number produced by dragonflies of other genera, because egg counts for the latter are not available. Neither is there any information in literature on the length of the incubation period of eggs in relation to temperature, except references to the arrestment of development in the eggs of some species over winter. Corbet, Longfield and Moore (1960) listed the incubation period of 23 species of British Odonata and Robert (1958) gave similar data for 24 continental species. There was no reference to temperature in either case. Likewise, the several American authors who have published complete life histories usually quoted the time from oviposition to hatching, but gave no indication of the temperatures to which the eggs were subjected, except that Krull (1929) stated eggs of *Sympetrum obtrusum* (Hagen) were held a 45° F., until hatching was desired.

During the past summer tests mere conducted to determine the number of eggs deposited by a female at one time and the effects of several levels of constant temperature upon the incubation period and the percentage of eggs which hatched.

To obtain eggs of known age three methods of collection were used. Females of the Libellulidae and the Gomphidae oviposit while flying over water, usually by striking the tip of the abdomen against the surface. If females of these species are caught while in the act of mating or ovipositing, eggs can almost always be obtained by holding the insects by the wings and "dipping" them so that the tip of the abdomen strikes the surface of water in a jar or other container. Very frequently females flying or resting near the water, and, sometimes, those taken far from water may be induced to deposit eggs by this method.

Females of the Aeshnidae and the Zygoptera oviposit by inserting their eggs into plant tissue. Thus, eggs may sometimes be obtained by observing oviposition and collecting the stem or leaf in which they have been placed. Of course, such plant tissue may also contain eggs, either of the same or of other species, deposited previous to the observation. Sometimes, females, specially of the Aeshnidae, may be induced to oviposit by holding or pinning them so that their feet and abdomen touch a stem or leaf.

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1. Purdue University Agricultural Experiment Station Journal Paper 2025.
2. Research from the Entomology Environment Laboratory.
3. Participants in the third Annual Summer Program in the Life Sciences for Secondary School Students of High Ability, Purdue Unversity, 1962.

Table 1. Accumulative percentages of eggs of several species of Odonata hatching at different temperatures at intervals after deposition.

Species	Number of Eggs[a]	Date	Clutch Number	Temperature[b]	Accumulative percentages of eggs hatching on days after deposition																												
					5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	37
Plathemis lydia (Drury)	1429	6/28	10	80				67	70		89	90	92	93	94																		
			10	75										70	95	96																	
			10	70								80	82	86	88	90	93																
Libellula pulchella (Drury)		7/18	15	80		64	84	92																									
			15	75			20	68																									
			15	70									4	28	52																		
	112	8/11	22D	R						4									21	40		42			48		49						52
Pachydiplax longipennis (Burmeister)	1060	6/21	1	R	16	59	73	78	83	84	85	86	88	90		91		92															
	1027	6/21	6	70									18		35	37	43		44	48		49				50							
	157	6/21	8	80c							M											22	39	42	43	44	45						
			8	70c							M														2	12	22	26	36	44	45	48	
	350+	7/6	11E	80			46	54	56																								
			11E	75							50	52																					
			11E	70								30	32																				
	86	7/6	11F	80		15	36	50	51	59	75	76	81	91	93	94	95																
Erythemis simplicicollis (Say)	990	6/21	2	R	2	20	36	42	49	51		52																					
Perithemis tenera (Say)	278	8/10	21B	R						75	76			82																			

[a] These numbers refer to the total number of eggs in a clutch. The number of eggs used in the temperature tests varied but usually was only a sample of the entire clutch.

[b] R = room temperature.

[c] First subjected to 60° for 11 days; then transferred (T) to 80° and 70° respectively.

The lots of eggs included in this study were obtained by all three methods—those of the eight species of Libellulidae by the dipping method, one lot of eggs of *Anax junius* (Drury) by holding a female in contact with a plant stem, and one of *Enallagma civile* (Hagen) by collecting a leaf of Polygonium in which a female was noted ovipositing.

The clutches of eggs counted included (in cases in which only a portion of a clutch was counted, the number counted followed by "+" is given):

Pachydiplax longipennis (Burmeister)—7:86, 157, 244, 350+, 350+, 1027, 1060.
Libellula pulchella (Drury)—3:112, 175+, 300+.
Libellula luctuosa (Burmeister)—1:125.
Plathemis lydia (Drury)—1:1429.
Perithemis tenera (Say)—3:107, 278, 590.
Erythemis simplicicollis (Say)—2:250, 990.
Sympetrum obtrusum (Hagen)—6:2, 6, 48, 80, 106, 126.
Sympetrum vicinum (Hagen)—2:23, 379.
Anax junius (Drury)—1:30.
Enallagma civile (Hagen)—1:223.

Eggs of eight clutches of five species were incubated at constant temperatures and several others at "room" temperatures. In some cases clutches were divided and the several lots of each were incubated at different temperatures, usually 60° to 80°F., at five degree intervals. Results of the experiments of the effects of temperature on the incubation period and the percentages of eggs hatching are summarized in Table 1.

Samples of each clutch or of different clutches incubated at 70°, 75° and 80° showed that hatching correlated with the temperature. The development was more rapid (that is, the eggs hatched in less time) and a higher percentage hatched at higher temperatures. However, different clutches incubated at the same temperature showed considerable variation, both in time and percentage of hatch.

Clutches incubated at "room temperature" usually showed a more extended hatching period than lots of eggs incubated at constant temperatures. This may be due to the separation of the eggs rather than to temperature conditions. Eggs of most species of Libellulidae have a gelatinous covering and tend to mass in large clusters when placed in small jars in the field for transportation to the laboratory. The eggs were probably more completely separated in the lots counted for the temperature tests than were those incubated at "room temperature."

Several clutches, or samples of eggs were incubated at 60° and 65° but none hatched. Except for one lot of eggs of *Sympetrum obtrusum* of which detailed counts are not available, none other than the two indicated in the table (*P. longipennis*—clutch no. 8) hatched when first exposed to 60° or 65° and later transferred to a higher temperature. All were exposed to the lower temperatures for more than 11 days.

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Interesting Diptera Collected in Indiana Walnut Groves

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Bait traps, designed to capture *Rhagoletis suavis* (Loew), an economic pest of walnuts, were placed in a grove of black walnuts *(Juglans nigra)* on the Glen Berry farm near Monroe City, Indiana, during 1960, 1961, and 1962, to evaluate the relative effectiveness of a series of ammoniacal compounds as attractants for *Rhagoletis* spp. Six species of flies that could be confused with *R. suavis* were also captured and records made as to the dates they were captured and in what numbers.[1] Discovery of a heavy infestation of *R. suavis* in a small grove of Persian walnut *(Juglans regia)*, Carpathian strain, on the Alvin Spitts property near Vincennes, Indiana, made it possible to evaluate the effect of bait sprays for control of this fly. The purpose of this discussion is to record the species and numbers taken, especially with reference to *R. suavis*, and to comment briefly on the injury caused by *R. suavis*, and the control obtained with bait sprays.

The traps used for exposing the lures, designed after those described by Still (17), were sheltered half-pint jars of bait suspended below 6- x 8-inch pieces of yellow masonite, coated with Stikem.[2] Baits were emptied and replenished when deemed necessary, generally at 24- to 34-day intervals.

In the Berry grove the traps were hung at 6-foot intervals on a plastic rope suspended about 7 feet from the ground and connecting four black walnut trees spaced about 50 feet apart, in an approximate square. Enough trees were in the grove to make a canopy of walnut foliage over the traps. The Spitts property contained nine Persian walnut trees on which the branches reached to the ground. Four traps were suspended from branches about 5 feet from the ground. Traps were examined at weekly intervals. Captures of seven species of flies were recorded from July 19 to November 4, 1960, and from June 15 to November 3, 1961. In 1962 captures of *R. suavis* only were recorded from July 6 to October 26. In 1962 two species of flies not taken previously were identified.

Condylostylus sipho (Say), Family Dolichopodidae, the long-legged flies.—This was the most numerous of the species captured, 1,088 being taken in 1960 and 842 in 1961. Peak captures occurred in August, but specimens were taken from the week ending June 23, when traps were first placed, to October 20. Only two references to this species were found in a limited review of the literature. Bray and Triplehorn (3) stated that adults of the species were predacious on aphids infesting giant ragweed, and Boyce and LeRoux (5) observed adults feeding on adults of the European red mite (*Panonychus ulmi* (Koch)) on apple foliage near Hanow, Ontario.

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[1] Acknowledgments are made to Richard H. Foote and Curtis W. Sabrosky, dipterists of the Entomology Research Division.

[2] Trade name for polymerized butene, isobutene, and butane.

Clusia lateralis (Walker), Family Clusiidae, referred to as the smallbanded flies.—These flies are seldom seen. Only one specimen was picked up on the bait traps and that was between August 5 and 12 in 1960. No references to this species were readily found in the literature.

Rivellia quadrifasciata (Macquart), Family Otitidae, often referred to as the picture-winged flies, because of their pronounced black, brown, and yellow wing markings.—Only nine specimens of this fly were taken during 1960 and 1961. Collections were made from June 30 to August 18. Literature reviewed showed that this species occurs from Alabama northward through the midwestern States into North Dakota and eastward to New York. In Indiana, it has been reported from the sand dunes area and Namba (14) lists it as having been taken at Lafayette and Logansport.

Delphinia picta (F.), Family Otitidae.—Adults of this species were captured frequently, 32 in 1960 and 16 in 1961. Captures were recorded from June 23 through November 13 with peak catches occurring in August. Frost (9, 10) mentioned this species in his notes on Otitidae. It is known to occur from Maine to Minnesota and southward to Florida and Kansas. R. H. Foote, in correspondence, stated that despite its widespread occurrence very little is known about this insect.

Pseudotephritis vau (Say), Family Otitidae.—Only a limited number of these flies were captured, six each year. They were found from August 12 to November 13, but most of them were captured between September 9 and 22. Numerous references to this species are present in the literature. Holmquist (12) and Brues (7) stated that larvae were found under the bark of trees. Townsend (18) observed adults in a woods near Urbana, Illinois, from April 17 through August 4. They were reported by Bray and Triplehorn (3) as present in Delaware.

During the course of the study, four species of Tephritidae, commonly referred to as the fruit flies and peacock flies, were captured. This family contains numerous injurious species, and the literature contains numerous references to the family. One of the better summaries of their biology is that of Christenson and Foote (8). Three of these species captured are recognized as economic pests of plants.

Zonosemata electa (Say), the pepper maggot, was taken in the Spitts grove, which was underplanted with garden vegetables, in 1962. It was discussed by Peterson (15) and others as a pest of peppers and eggplants. It has also been found in tomatoes. Benjamin (2) stated that it is present in Florida and Georgia.

Straussia longipennis (Wiedemann), commonly known as the sunflower maggot, was also collected from traps operated in the Spitts grove in 1962.

Tomoplagia obliqua (Say) was taken in the black walnut grove between August 5 and 12, six specimens in 1960 and three in 1961. This species was originally described from Indiana by Say in 1830 (16). Benjamin (2) reviewed the literature pertaining to this species and listed the flowers of *Vernonia scaberrima*, *V. blodetti*, and *V. gigantea* (Iron-Weeds) as hosts.

Rhagoletis suavis (Loew), sometimes referred to as the walnut husk maggot, is a common pest of black walnuts and butternuts *(Juglans cinerea)* throughout the eastern United States. Its range of habitat is the same as the plantings for the above nut trees. Adults deposit a mass of eggs in the shucks of the nuts and the larvae develop in the shucks, feeding between the shuck and shell. Since they feed in mass, it seems obvious that the quality of the nut is impaired; however, the most severe injury is to the thinner shelled Persian walnuts. Feeding by the larvae causes the shucks of the nuts to stick to the shell. The nut meats are malformed and, in most instances, shriveled and improperly developed so that they cannot be used. A near relative, *Rhagoletis completa* (Cresson), called the walnut husk fly, is enough of a pest to Persian walnuts in lower California to necessitate one to two spray applications a year in order to grow marketable nuts. Fortunately, *R. suavis* has not been introduced into the western areas of the United States where the Persian nut groves are concentrated. A partial review of the literature revealed the following more important referencs: Babb (1), Loew (13), Brooks (6), Gambrell (11), and Boyce (4), who discussed related species attacking walnuts and their general distribution.

In the black walnut grove 419 *R. suavis* adults were captured in 1960, 83 in 1961, and 84 in 1962. Captures were made from between July 22 and 29 into the week ending October 14 in 1960, from between July 28 and August 4 into the week ending November 3 in 1961, and from between July 6 and 13 into the week ending October 26 in 1962. In 1962 four traps in the Persian walnut grove captured 262 *R. suavis* adults, the first between July 6 and 13. Between 50 and 60 adults were taken from the four traps each week from August 1 to 21. For the three seasons, captures increased rapidly the last week in July and reached a peak between August 10 and 31. A second but smaller peak occurred between the middle and last of September.

Several ammoniacal compounds were attractive to the species, more so than the glycine baits. However, none of a number of coded compounds supplied by chemists of the Entomology Research Division were more attractive than dibasic ammonium phosphate or ammonium carbonate. Pyridine was highly effective but volatilized rapidly. Neither Staley's No. 2[3] and 7[4] protein hydrolysate baits nor brown sugar alone or in combination with dibasic ammonium phosphate or ammonium carbonate was more attractive than the dry ammonium compounds. After two seasons' studies, it was concluded that dry lump ammonium carbonate, placed in a ½-pint jar, was the most efficient bait tested. Studies in 1962 showed that the amount of ammonium carbonate used could be reduced by sealing the jar, except for two pieces of plastic hose $\frac{5}{16}$ inch in diameter extended from inside the jar to the center of the trap board.

Fewer flies were taken per trap in the black walnut grove than in the Persian walnut grove. It was believed that this was due, in part, to the location of the traps in relation to the walnut foliage. Traps in the

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[3] Protein hydrolysate from corn protein.

[4] Protein hydrolysate from corn protein and steep water.

Persian walnut grove were hung in the foliage, whereas those in the black walnut grove were about 20 feet below the branches.

For several years prior to 1962, injury by *R. suavis* was severe enough in the Spitts grove to completely destroy the Persian walnut crop. In 1962 malathion-Staley No. 7 protein hydrolysate bait sprays, containing 4 pounds 25-percent wettable-powder malathion with 1 quart Staley's bait in 100 gallons at the rate of 25 gallons per tree, applied to seven of the nine trees in the grove August 1 and 21, reduced injury by this insect to a low level. The sprayed trees averaged 75 pounds of nuts each, more than 99% of which were free of injury. Fly captures were greatly reduced for 2 weeks following each spray.

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Further Notes on Rates of Development of the Naiads of *Neotetrum pulchellum* (Drury) (Odonata: Libelluidae)[1]

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We have reported previously (Montgomery and Macklin, 1962) of the effect of photoperiod and temperature upon the length of the time from collection of final instar naiads to emergence of adults of *Neotetrum pulchellum* (Drury). This period was found to average 40.5 days for naiads collected November 8, and almost 32 days for those collected December 24, at approximately 80° F., in a 16 hour photoperiod. This time was approximately the same for a photoperiod of 24 hours (continuous light) and for three periods of three hours each equally spaced throughout the 24 hour period. With a photoperiod of 11 hours at both 70° and 80°, this period was considerably longer (90.7 and 77.7 days, respectively, for the November collection and 52.2 days at 70° for the December collection).

Another collection was made from the same population April 10, 1962, and reared to emergence in ten lots. Of 60 ultimate instar naiads collected, 58 survived to emergence. Ten lots of six naiads each were subjected to different conditions of photoperiod or light quality (wave length), all at an approximately constant temperature of 80° F. There were four photoperiods of 24 (continuous), 16, 12, and nine hours of light in each 24 hour period and two with nine hours of light divided into three periods of three hours each and six periods of one and one-half hours each, equally spaced in the 24 hour period. Four colored lights—red, green, blue and "black"—with a 16 hour photoperiod were also included.

Rearing conditions were the same as previously described (Montgomery and Macklin, 1962). The naiads were maintained in pint "wide-mouth tapering can or freeze jars" with approximately 200 ml. of water and fed "white worms" (Enchytraeidae). The rearing cabinets consist of

TABLE 1. Characteristics of energy emitted by colored lamps.

	Peak	Percentage of energy emitted		
		Middle Ultra-violet 2800-3200A	Near Ultra-violet 3200-4000A	Visible 4000-7600A
Red	6000-7600A	0.0	0.0	100
Green	5000-6000A	0.28	1.43	98.3
Blue	4000-5000A	0.5	11.1	88.4
"Black"	3400-3800A	2.68	86.8	10.05

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[1] Purdue University Agricultural Experiment Station Journal Paper No. 2027.

[2] Research from the Entomology Environment Laboratory.

TABLE 2. Numbers of naiads of *Neotetrum pulchellum* (Drury) collected April 10 completing developments at intervals during continuous exposure to different photoperiod and light quality. Lafayette, Indiana, 1962.

Photoperiod[a] and light quality	Days										Ave.	Earlier Collections[d] Range and Average (days)	
	16	17	18	19	20	21	22	23	25	30		Nov. 8	Dec. 24
24		2	2		2						18.66	31—37 33.3	33—37 35.0
16		4	1								17.20	37—44 40.5	30—35 31.8
16 Black		1	5								17.87		
16 Red	1	4	1								17.0		
16 Green	3	2			1						17.0		
16 Blue	3	2									16.40		
12					4	1	1				20.50		
9			2		2			1		1	21.50	51—75 65.8	
3—3[b]	1	2	2	1							17.50		35—48 41.8
6—1½[c]				4			1		1		20.50		

[a] Numbers indicate the hours of light within each 24 hour period; unless indicated otherwise white light was used.

[b] Three equally spaced 3 hour periods in each 24 hours.

[c] Six equally spaced 1½ hour periods in each 24 hours.

[d] Summary of comparable data from previously published report (Montgomery & Macklin 1962).

wood-chambers, approximately 2x2x3 feet, in triple units (with one separate unit). Light is provided by a 15-watt fluorescent lamp in each chamber with an independent photoperiod control clock. White light was supplied with ordinary 18-inch lamps ("Champion F 15 T 8/W"). The colored light was furnished by lamps (all 18 inch, 15-watt, fluorescent), producing energy (in percentages) in several ranges as shown in Table 1.

The results of the rearings of the April 10 collection are given in Table 2. The statistical analysis of these results indicate highly significant differences among the treatments. (The F ratio is 5.26723, with 2.9 required for significant difference at the 1% level. The differences required for significance between any two treatments are 2.2 at 5% and 2.69 at 1% level.)

From this analysis there appears to be no significant differences due to colored light, nor any among the 24, 16 and 3-3 hour photoperiods. The 12, 9 and 6-1.5 hour photoperiods differ significantly from the former treatments, but not from each other. It is of interest that nine hours of light divided into three periods produces results almost identical with a 16 hour photoperiod, but that further division (six periods of one and one-half hours each) produces results identical with a 12 hour period and not significantly different from nine hours.

Comparison with the results of experiments with earlier collections indicate that some development occurred "in nature" between November 8 and December 24 and a considerable amount (equivalent to approximately half of the remaining time required to complete naiadal development) between December 24 and April 10.

In all tests to date (except the 24 hour period of the November collection) any departure from a 16 hour photoperiod induces a longer average period from development. While there is some overlap, almost all individuals require a somewhat longer period, but the major portion of the longer average time is due to a few individuals. At 16 hours the development is almost constant, while at other periods there are considerable differences in the rates of development of individuals.

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Response of the House Fly, *Musca domestica* L., to Electric Lamps

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Experiments to determine the response of the house fly (*Musca domestica* L.) to electric lamps emitting different intensities, wavelengths and types of spectra of electromagnetic energy were conducted in 1952 and 1953. In 1953 and 1954 experiments were conducted to determine the time of day the house fly is most attracted to a 15-watt fluorescent 360 BL blacklight lamp. All experiments were conducted in the veterinary science and the swine nutrition barns at Purdue University.

TABLE 1. Spectral energy distribution of various lamps[1]

Lamps	Kind of Spectrum	Energy output in watts					
		Ultraviolet			Visible		
		Below 2800A	2800-3200A	3200-3800A	3800-5000A	5000-6000A	6000-7600A
Glow Lamp							
Argon (4-w)[3]	Divided		about 85% emitted here		about 8% here		about 7% here
Mercury							
Germicidal (4-w)	Line	0.5	0.01	0.01	0.04	0.02	0.001
Germicidal (15-w)	Line	3.0	0.06	0.05	0.17	0.09	0.005
Fluorescent							
360 BL Blacklight (15-w)	fluorescent	0.0	——	2.10	0.31	0.09	0.000
Blue (40-w)[2]	fluorescent	0.0	0.02	0.50	6.50	2.20	0.150
Daylight (40-w)[2]	fluorescent	0.0	0.08	0.22	2.50	3.50	1.800
Gold (40-w)[2]	fluorescent	0.0	0.00	——	0.00	2.70	1.800
Green (40-w)[2]	fluorescent	0.0	0.10	0.15	1.40	6.30	0.100
Pink (40-w)[2]	fluorescent	0.0	0.02	0.08	0.70	1.30	3.700
Red (40-w)[2]	fluorescent	0.0	0.00	——	0.00	0.03	0.970
Incandescent							
Standard (100-w)[2]	Continuous	0.0	0.00	0.06	0.90	2.25	6.800

[1] Data from Publication LS 125 and LS 135, Engineering Division, Lamp Department, General Electric Company, Cleveland 12, Ohio.

[2] Size shown not used in experiment, but spectral distribution of the lamps used should be similar. N oquantative data were available for lamps used but not shown in above table.

[3] No completely comparable quantitative data available. Information computed from graphs.

The following lamps, the approximate energy distribution of some of which are given in Table 1, were used in the experiments: 4- and

15-watt germicidal Mercury (line spectrum); 15-watt blue, gold, pink, red, 360 BL blacklight and filtered Blacklite fluorescent (fluorescent spectrum); 15-watt clear, blue and red, 25-, 60-, 200- and 300-watt inside-frosted incandescent (continuous spectrum); and a 2-watt argon glow lamp (divided spectrum: 3100-4700 A and 6800-7600 + A).

Two types of traps were used: a fan-type cylindrical trap known as the New Jersey mosquito trap and an 18" x 18" electrocutor grid.

Response of House Flies to Various Lamps

Experiments Using Electrocutor Grids:

In preliminary tests it was found that some flies came to a charged electrocutor grid when the lamps were not lighted. It was not determined whether these flies were attracted by the coronal discharge at the end of the grid wires, by the electromagnetic and/or electrostatic field around the charged grid or by the ozone produced, or whether they just blundered into the grid.

The electrocutor grids were used in two separate experiments. The objective of the first experiment was to determine if house flies are attracted to a 15-watt 360 BL blacklight fluorescent lamp. In this experiment two 18" x 18" electrocutor grids, one equipped with a 360 BL lamp and the other without a lamp, were used. The experiment ran for 14 days and the lamp was moved daily from one trap to the other to eliminate differences due to location. The electrocuted flies dropped into a basket suspended beneath each grid and were counted daily. The average daily catch of house flies (238) by the trap equipped with the 360 BL lamp was over five times the number (43) caught at the trap without a lamp.

The objective of the second experiment was to compare the attractiveness of the following lamps to that of a 15-watt 360 BL blacklight fluorescent lamp that had burned for over 100 hours: 25-, 200- and 300-watt inside frosted incandescent lamps; 15-watt germicidal; 15-watt blue, gold, green, pink, red, filtered Blacklite, and new (unburned) 360 BL blacklight fluorescent lamps. Two grids were used in each test, one being equipped with the "burned-in" 360 BL lamp and the other with one of the lamps being compared. Each test was repeated six times and the traps were rotated daily. The results, as shown in Table 2, were recorded as per cent of the catch by the "burned-in" 360 BL lamp.

As shown in Table 2 the "burned-in" 15-watt 360 BL blacklight fluorescent lamp attracted more house flies than any of the other kinds of lamps tested except the new 360 BL lamp. The amount of energy emitted by 360 BL blacklight lamps decreases about 10% during the first 100 hours of burning. Therefore, the 10% difference in attractiveness between the "new" and the "burned-in" 360 BL lamps can be logically attributed to the 10% difference in energy out-put. As the intensity of the white inside-frosted incandescent lamps increased from 25-watt up to 300-watts their relative attractiveness increased from 35.5 to 49.9 per cent when compared with the trap equipped with a 15-watt 360 BL lamp. A 15-watt germicidal lamp proved to be less attractive than the 360 BL and the filtered Blacklite fluorescent, as attractive as the

300-watt incandescent, and more attractive than any of the other lamps tested.

TABLE 2. Per cent of house flies caught by traps lighted with various lamps when compared with the catch at a trap lighted with a 15-watt 360 BL lamp. Lafayette, Indiana, July 21-September 23, 1953.

Flies caught at 360 BL lamp	Size and Type of Lamps Tested	Per cent of 360 BL catch
140	15-w gold fluorescent	15.7
300	15-w red fluorescent	16.7
325	15-w green fluorescent	16.9
395	15-w blue fluorescent	17.7
130	15-w pink fluorescent	23.1
335	15-w daylight fluorescent	25.4
155	25-w incandescent	35.5
454	200-w incandescent	37.0
295	15-w germicidal	49.1
1910	300-w incandescent	49.9
330	15-w filtered Blacklite fluorescent	78.7
350	15-w 360 BL, blacklight fluorescent (new)	110.0

From the results of these tests it may be stated as a general conclusion that wavelengths of electromagnetic energy between 3200 and 3800 A in length are more attractive to the house fly than shorter or longer wavelengths, and that the higher the energy out-put in lamps with the same type of spectrum and energy distribution, the more attractive they are.

Experiments Using Fan-type Traps:

The objective of these experiments was to determine the attractiveness of lamps of different intensities, wavelengths and types of spectra to house flies. The following lamps were tested: a 2-watt argon glow; a 4-watt germicidal; a 15-watt clear, a 20-watt blue, a 20-watt red, and a 15- and a 60-watt inside-frosted incandescent.

The traps used in these tests are known as New Jersey Mosquito traps. They are equipped with a fan which draws the insects down into a killing chamber. In preliminary tests it was found that a few flies were caught in these traps when the lamps and the fans were not operating and that when the fan was operated in an unlighted trap the number of flies caught increased about nine times.

In each of the tests in this series of experiments three traps were used. The traps were rotated daily so as to eliminate the effect of position. Five tests, using different combinations of lamps, were run. Each test was carried out for six days. The lamps were kept lighted at all times.

The lamps used in each test and the results obtained are given in Table 3.

TABLE 3. Average number of house flies caught with fan-type traps equipped with various lamps. Lafayette, Indiana, July 21-September 2, 1953.

Test No.	Ave. No. Flies Caught Per Day			L.S.D. At 5 per cent
1	60-w Frost. Incan.	25-w Frost Incan.	No Lamp	
	2675	2480	1430	980
2	25-w Frost. Incan.	15-w Clear Incan.	No Lamp	
	432	338	253	114
3	60-w Frost. Incan.	25-w Frost. Incan.	2-w Argon	
	542	469	376	87
4	25-w Frost. Incan.	20-w Blue Incan.	20-w Red Incan.	
	367	298	320	66
5	25-w Frost. Incan.	20-w Red Incan.	4-w Germicidal	
	191	238	318	60

Both a 25-watt and a 60-watt inside-frosted incandescent lamp proved to be attractive to house flies (Test 1) and both proved to be more attractive than a 2-watt argon glow lamp (Test 3); however, the difference in the attractiveness of these two lamps (Tests 1 and 3) was not significant at the 5% level.

Although a trap equipped with a 15-watt clear incandescent lamp caught more flies than did one without a lamp, the difference in the numbers caught was not significant.

The 25-watt inside-frosted incandescent lamp was more attractive than a 20-watt blue incandescent (Test 4), but it was not more attractive than a 20-watt red incandescent one (Tests 4 and 5). The difference between the number of flies attracted to a 20-watt blue and a 20-watt red incandescent lamp was not significant (Test 4).

As shown in Test 5, a 4-watt germicidal lamp, which has a line spectrum and which emits most of its energy below 2800 A, was much more attractive than either a 25-watt inside-frosted or a 20-watt red incandescent lamp which have a continuous spectrum and emit but little or no energy in the ultraviolet region of the spectrum.

Time of Day House Flies Attracted to 360 BL Lamp

Three experiments were conducted in 1953 to determine whether the house fly is more attracted to a 360 BL lamp at night or during the daytime. Two electrocutor grids were used in each of these tests and each test was run for six days. In all of the tests one grid was illuminated continuously with a 15-watt 360 BL lamp. In the first test the other grid was illuminated with a 15-watt 360 BL lamp from sundown to sunrise (6:45 P.M. to 4:30 A.M. C.S.T.): in the second test the second grid was illuminated from 6:00 P.M. to 6:00 A.M.; and in the third test the second grid was illuminated from 6 A.M. to 6 P.M. The grids were alternated daily.

In the first test the trap which was illuminated from 6:45 P.M. to 4:30 A.M. caught on a daily average 64.6 per cent as many flies (278 to 430) as did the trap which was illuminated for 24 hours. In the second test the trap which was illuminated from 6:00 P.M. to 6:00 A.M. caught 64.3 per cent as many flies (360 to 560) as the continuously illuminated one. The trap which was illuminated from 6:00 A.M. to 6:00 P.M. caught but 41.8 per cent as many flies (140 to 335) as did the one which was illuminated continuously. All of these results agree that more flies are attracted to a 15-watt 360 BL lamp at night than during the daytime.

In 1954 a test was conducted to determine when, within the limits of one hour, houseflies are most attracted to an electrocutor grid equipped with one 15-watt 360 BL lamp. This test was conducted in the swine nutrition barn which was screened. This screening insured that the population of flies was fairly constant throughout any 24-hour period and that the results were not complicated by the migration of flies to and from the building. The test was conducted for eight 24-hour periods between September 23 and October 13. The time of sunset varied from 5:44 P.M. (Sept. 23) to 5:10 P.M. (Oct. 13), a total of 34

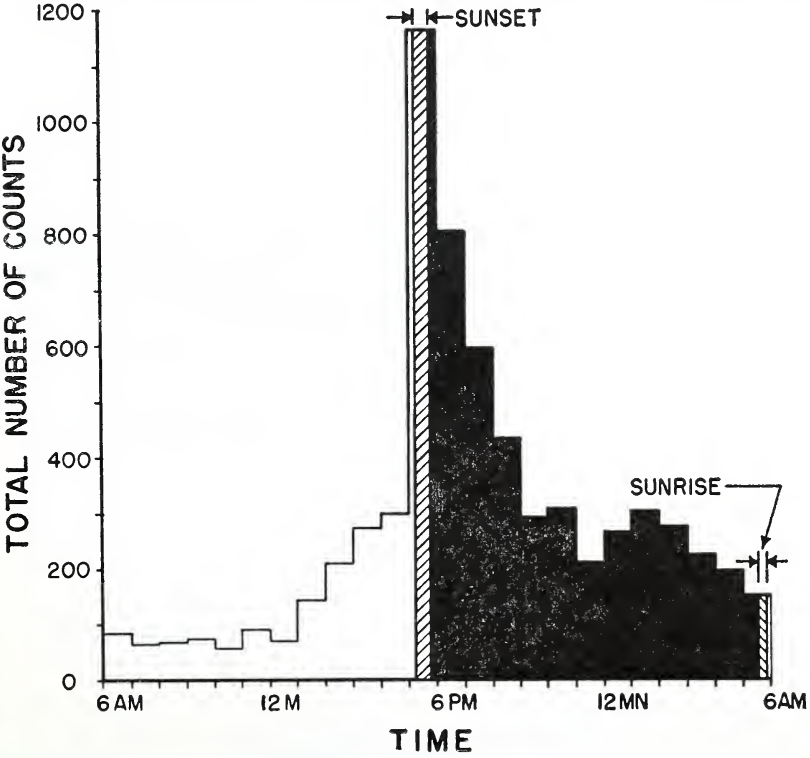

Figure 1

minutes. The number of flies electrocuted by the grid was automatically recorded on an accumulative digital counter. This was operated by current impulses caused by the grid being momentarily shortened when the flies contacted it. A new counter was switched automatically into the circuit at the end of each hour.

As shown in Figure 1, few flies came to the trap from sunrise until 1:00 P.M. There was a gradual increase from then until 5:00 P.M., one-half hour before sunset. During the hour in which the sun set, 5:00 to 6:00 P.M., the flies came to the trap in great numbers, 17 per cent of the total being caught during this time. After sunset there was a rather sharp hourly decrease until 9 o'clock. As in the 1953 experiments, over 60 per cent of the flies came to the traps at night.

The Occurrence of the Cereal Leaf Beetle, *Oulema melanopa* (L.), in Indiana, 1962

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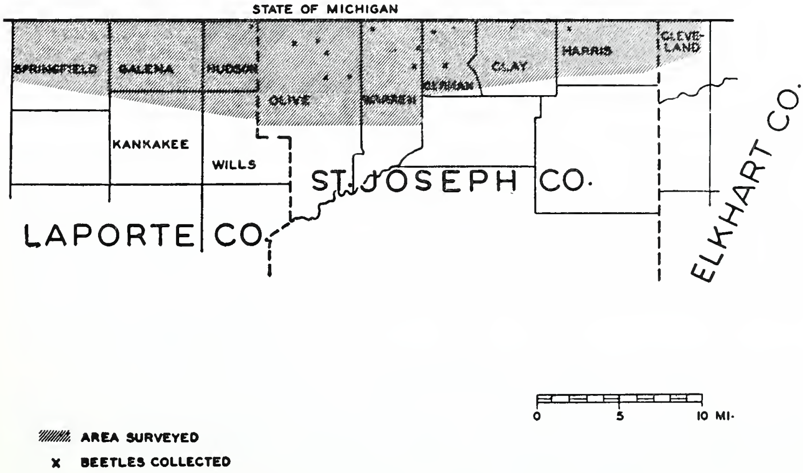
The cereal leaf beetle, *Oulema melanopa* (L.), a serious pest of cereal crops in certain areas of Europe, Asia and Africa, was found to occur in the United States for the first time early this summer in southwestern Michigan. A preliminary survey conducted by the Division of Entomology on August 9, 1962 indicated the presence of this potentially serious pest in northern Indiana immediately south of the infested area in Michigan. Immediate plans were made to conduct a more extensive survey in northern Indiana to determine the extent of the insect's movement and distribution, the degree of infestation, and to gather, if possible, information on host range and favorable habitat.

The area covered by this survey conducted August 13-17, 1962 was approximately two hundred square miles directly south of the Indiana-Michigan state line. It is six miles wide and about thirty-five miles long extending east of Michigan City to Elkhart and covers parts of LaPorte, St. Joseph, and Elkhart Counties. Since *Oulema melanopa* (L.) is known to attack cereal crops, corn fields and vegetation adjacent to them as well as oat and wheat stubble were directly examined for the detection of this pest and its typical feeding signs. Collections of the cereal leaf beetle were also made by sweeping the vegetation with a standard beating net. Fifty double sweeps were made at each site sampled, since fewer sweeps failed to recover beetles from a known in-



DISTRIBUTION OF THE LEAF BEETLE, *OULEMA MELANOPA* (L.) IN INDIANA — 1962 fested field where positive collections were made a week earlier. About ninety-seven stops were made at one mile intervals or wherever sites suitable for feeding and shelter of this beetle were found.

The survey results indicate that *Oulema melanopa* (L.) has successfully moved into the State of Indiana and is distributed, though in extremely low populations, over an area of about sixty square miles. (Fig. 1). Positive collections were made in twelve different locations in Olive, Warren, German, and Harris Townships in St. Joseph County and in one location in the northeast corner of Hudson Township in LaPorte County. No beetles were found in Elkhart County. The number of beetles caught at each positive collection site ranged up to five beetles. Cursory examinations and sweeping at likely locations in other sections of the state not extensively surveyed were all negative.

No beetles were present on corn at any of the sites examined nor were the characteristic feeding signs noted. Beetles were collected by sweeping only from vegetation adjacent to corn and to oat or wheat stubble. Such vegetation consisted of a mixture of weeds and grasses, including ragweed, lambs-quarter, smart-weed, curled-dock, chicory, foxtail, timothy, quack grass, and orchard grass.

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The West Lafayette Mosquito Control Program

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The mosquito control program in West Lafayette was initiated in 1959 as a co-operative effort between the city of West Lafayette and the Entomology Department of Purdue University. Prior to this program a critical problem existed primarily as a result of the large number of areas in and around the city suitable for larval development. The purpose of this program is to reduce the biting population of mosquitoes to a negligible count.

The control operation consisted of two phases. The first of these was directed at the larvae. A basic survey was conducted at the beginning of the summer to find and map the likely areas for larval development. These surveys were valuable, as they showed the species of mosquitoes present, the breeding areas and the flight range of the various species. With this information available, it was possible to determine the advisability of treating the individual area.

An enameled dipper with a long handle was used to pick up the larvae while surveying. The surface feeding Anopheline mosquitoes could usually be captured by lowering the dipper into the water and allowing the water to flow into the dipper carrying the larvae with it. Generally the *aedes* and *culex* larvae required a quicker and deeper action with the dipper. An estimate of the larval population could be determined by counting the larvae in one dipper of the water.

In some situations one treatment with the 2 percent heptachlor granules provided control for the entire summer. This was true of most temporary pools where there was little or no run-off. In situations where there was running water part of the time, more treatments were usually required.

One control problem arose which required a different treatment that most of the others. Large number of *Aedes vexans* (Meigen) and *Psorophora ciliata* (Fabricius) were found in large numbers in a field on McCormick Road west of the Purdue University Campus. This field is owned by the Purdue University Dairy Department and is used as pasture for dairy cattle. This ruled out the use of the chlorinated hydrocarbon insecticides because of their long residual effect and the possible accumulation of residues in milk. A spray of 1 percent DDVP was used to spray the ditches, and the cattle were not allowed to re-enter the field for a period of four days as a safety precaution. Each time the ditches were flooded, more eggs were covered by the water, and another treatment was required.

Another important source of mosquitoes is Happy Hollow, a city park on the northeast side of the city. It consists of a maze of ravines through which a brook and its numerous tributaries run. After a rain there is running water in these ravines. During dry periods there are numerous small pools which usually contain large populations of *Culex restuans* (Theobald) and *Anopheles punctipennis* (Say). This area must be treated several times during the summer since the residue of the larvicide was diluted with each rain.

A field on the northern edge of the city limits was a problem area of major importance early in the summer. It is on the highway 52 by-pass at the edge of a large housing development. Much of the field was flooded after each rain and was heavily populated with the larvae of *Aedes vexans* (Meigen). Here the residual effect from one treatment was sufficient to provide control for the entire summer.

Aedes triseriatis (Say) was commonly encountered in the Grandview Cemetery in tree holes and in containers with decaying plants. A periodical survey was made of the cemetery, a junkyard, various trash-piles, and other places where water was likely to be standing. Other areas of occasional importance included a landfill area south of the city which had both temporary and permanent water pools; McCormick Woods where *Aedes trivittatus* (Coquillet) was found; and an area on Sycamore Lane where temporary pools formed by removal of earth for road construction contained *Psorophora confinnis* (Aitken).

It was interesting to note the shift of the larval problem from one area or type of environment to another. During dry weather Happy Hollow was an active site of larval development. When a heavy rain came, it made Happy Hollow and similar areas unsuitable for larvae, but it flooded the temporary pools and tree holes. By the time the temporary pools had dried up, the pools in Happy Hollow again contained larvae.

The second phase of this control program is directed at the adults. It was accomplished by a systematic fogging program. The city was divided into sixteen sections according to size, location, and the direction of the streets. The fogging was done with a Curtis Dyna-fog thermal aerosol generator using a 5 percent by weight solution of DDT in fuel oil. The fog machine was set to put out twenty gallons of the solution per hour.

The maximum speed of the truck during fogging is five miles per hour. The fog is effective for an estimated swath of one hundred feet. This was variable, depending on the wind.

The whole city was fogged once before any one section was retreated. This served to eliminate the initial population of adult mosquitoes. After the city was completely covered the first time, the fogging was concentrated on the areas where it was most needed. In many instances the direction and velocity of the wind was a decisive factor in selecting the section to be fogged. An area can be fogged most effectively if the direction of the wind is perpendicular to the direction of the streets in the area. Wind velocity is also a big factor in fogging. Generally an area which is unsheltered cannot be fogged effectively if the wind is very strong at all, while an area with many large trees and numerous large buildings required a stronger wind to carry the fog. Another very important factor in fogging is convection currents produced by warm air rising in the evening and carrying the fog with it. The fog was most effective when it remained near the ground for long periods of time and drifted very slowly.

Both fogging and larviciding operations were essential to the success of the control program.

GEOLOGY AND GEOGRAPHY

Chairman: LOWELL DILLON, Ball State College
WILLIAM KOWITZ, Valparaiso University, was elected chairman for 1963

ABSTRACTS

A Programme for Physical Geography: abstract of a paper for presentation to the Indiana Academy of Sciences, October, 1962. B. J. GARNIER, Professor of Geography, Indiana University.—Geography is logically acceptable as an earth science if it is realized that the subject deals with the features of the earth, considering them from the viewpoint of their inter-relationships and distinctive combinations in different areas. It follows from this, that physical geography concerns itself with physical earth features—land, soil, plants, air, and water—the inter-relationships between them, and how their combination contributes to the character of different parts of the world. Each earth feature in which a physical geographer is interested is itself the object of intensive study by one of the systematic sciences. Geography differs from these sciences because its viewpoint concentrates attention upon phenomena significant for inter-relationships at the earth's surface, such as the physique of the terrain, the nature of soil and plant covering, conditions in the lower atmosphere, and the heat and moisture balance at the earth's surface.

The proper development of physical geography along these lines depends on the existence of sound undergraduate and graduate courses. Undergraduate work should include not only the elementary first-year introductory courses in physical geography widely found in Colleges today, but also one or more senior-level courses in advanced physical geography. The latter should be open not only to those with a geographical background, but also to those without such background but who have had specified courses in the systematic sciences. Graduate courses and research programmes should likewise be open to both geography majors and suitably qualified majors in related sciences. This cross-fertilization will maintain high scientific standards in physical geography, and at the same time demonstrate to a wide and critical audience the nature of geography's contribution to scientific knowledge.

Lithologic and Organic Criteria for a Lake Estuarine Environment and the Geologic Development of a Lake Estuary as Studied in Sabine Lake and Vicinity, Texas-Louisiana. HENRY E. KANE, Ball State Teachers College.—Certain lithologic and organic criteria were established for the Recent sediments of a lake estuarine environment, Sabine Lake, Texas-Louisiana, and were compared with criteria established for the Recent sediments of a nearshore neritic environment, the Gulf of Mexico. The organic criteria, especially the Foraminifera, along with the geomorphology and geology of the area, were used to develop the Late Quaternary history of the lake estuary which was coordinated with the Late Quaternary history of the North Central Gulf Coastal Plain.

Seventy-four cores and 20 clam shell samples were taken from Sabine Lake and the Gulf of Mexico. Data from these cores and samples were used to map the types and distribution of the sediments and microfauna of the two environments. Data from auger and bore holes and from topographic maps and aerial photographs were used to establish the history of the geomorphic evolution of the lake estuary and the geology of Sabine Lake and vicinity.

Geomorphic evidence indicates that Sabine Lake occupies the former valley of the Neches and Sabine rivers which is entrenched into Late Pleistocene deposits to a minimum depth of 120 feet at the Gulf of Mexico shoreline. This valley has been filled in by the streams and closed off at its southern end, except for Sabine Pass, by the progradation of the Gulf shoreline to form the present lake estuary. The erosion and subsequent alluviation were caused by a fall and rise in sea level due to waxing and waning of continental glaciers in Late Quaternary time.

Lithologic criteria are not sufficiently distinctive to differentiate the lake estuarine and the nearshore neritic environments.

Organic criteria, especially the foraminiferal biofacies, can be used to differentiate the two environments and to substantiate the geomorphic evidence for the development of Sabine Lake. The types and distribution of the biofacies of the bottom sediments of Sabine Lake differ from those of the Gulf of Mexico, and also differ from those of the deeper sediments in Sabine Lake taken 3 feet and 6 feet below the bottom sediments. The biofacies of the deeper sediments of the lake are similar to those of the bottom sediments of the southern portion of the lake and the present Gulf. The distribution of the biofacies apparently is affected by salinity variations of the water bodies. At the time of deposition of the deeper sediments, the more saline waters of the Gulf of Mexico circulated freely into the open entrenched valley now occupied by Sabine Lake before its southern end was restricted by filling of the valley and progradation of the Gulf shoreline.

Some Linear Glacial Features in West-Central Indiana.[1] ALLAN F. SCHNEIDER, GERALD H. JOHNSON, and WILLIAM J. WAYNE, Indiana Geological Survey.—Recognition of numerous linear features of glacial origin suggests that the sequence of glacial events in Indiana during the Wisconsin Age should be restudied. Three sets of linear features in west-central Indiana are described here. (1) Virtually straight shallow troughs and discontinuous low ridges or elongated knobs composed in most places of sand and gravel occur in a belt about 50 miles long between northwestern Tippecanoe County and southeastern Boone County. The consistent northeast-southwest orientation of these features forms a striking subparallel pattern that indicates ice movement from the northeast. Whether these forms are closely related in time and mode of origin to the complex system of drainageways and eskers in east-central Indiana is not known. (2) Gently rounded swells or weakly developed drumlinoid features, which rise about 20 feet above intervening swales, mark the ground moraine in southern Cass County and northwestern Howard County. The east-west orientation of the swells and the parallel pattern of westward-flowing streams strongly suggest ice movement from east to west in this area. (3) Discontinuous low ridges composed largely of sand and gravel are present within and adjacent to a weakly to moderately developed morainic belt (Iroquois Moraine or Marseilles Moraine of various authors) that trends across central Jasper and central Newton Counties. Although these forms are here referred to as eskers, they may be crevasse fillings; in either case they are believed to be oriented nearly parallel to the direction of movement of the ice that formed them. Only two of the features are well defined, both of which trend about N. 60° W., but the absolute direction of ice movement in this area is unknown.

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1. Published with permission of the State Geologist, Indiana Department of Conservation, Geological Survey.

Dubois County, an Exception to the General Trend

LOWELL I. DILLON, Ball State Teachers College

Introduction

Southwestern Indiana has been described at various times in the past as a depressed area, a region of population decline, and an area of economic stagnation. All these statements are, in part at least, true. Such statements are, however, much too inclusive, for, in the heart of this area, Dubois County provides an outstanding exception to them.

Major Differences Between Dubois and Surrounding Counties

(1) Dubois County has gained in population every decade since 1910. Total gain during the 1910-1960 period was 7,620 or 38.4%. Except for Vanderburgh County, no other southwestern Indiana county has shown such consistent growth (1). Vanderburgh County, containing the city of Evansville, is the only metropolitan area in southwestern Indiana and, as such, is not strictly comparable to its more rural neighbors.

(2) The peak population of Dubois County (27,463) was reached in 1960. The only other counties of the area having a 1960 peak were Vanderburgh, Warrick, and Lawrence. In the case of Warrick recent growth has been confined to the western townships, all within easy commuting distance of Evansville and undoubtedly was due chiefly to the influence of Evansville. Lawrence County, in turn, has been influenced by nearby growth in Bloomington, though perhaps to a lesser degree. In Dubois County, nine of the twelve townships gained during the 1950-1960 decade, and growth was definitely not caused by external influences.

(3) Population growth within Dubois County has been due to economic factors within that county rather than in adjoining areas. This is shown by the fact that, in 1960, only 4.6% of the working population of this county was employed outside its boundaries. Only five counties in the state had a lower percentage. Other percentages in southwestern Indiana ranged from 39.7% in Warrick to 4.7% in Vanderburgh with the majority of them exceeding 20%.

(4) According to the Indiana State Board of Health (2), Dubois County had one of the lowest net estimated emigration totals of the southwestern Indiana counties. Coupled with the fact that, at least over the past fourteen years, it has had a considerably higher birth rate than any of its neighbors (3), this figure also shows the comparative stability of its population. Emigration losses were somewhat lower in Warrick, Orange, and Washington Counties and Vanderburgh County showed a gain. In no case was the birth rate as high.

(5) Dubois County had a high percentage of industrial employment. In 1960, over 72% of the total labor force was engaged in manufacturing. Although nearby Perry County exceeded this with 81%, a total of only eight counties in the entire state ranked higher (4).

(6) Manufactural employment and value added by manufacturing have shown steady gains in Dubois County since well before World War II. Practically all other southwestern Indiana counties have shown considerable fluctuation during this period (5).

(7) Mean annual individual income, although lower than that of numerous central and northern Indiana counties, has consistently ranked higher than that in most of the surrounding area. In 1960, Dubois County, with an average of $3,089 was outranked within the area only by a Vanderburgh and Knox Counties with figures of $3,575 and $3,115 respectively.

The above facts definitely show that, in contrast to most of southwestern Indiana, Dubois County has been an area of steady population and industrial growth and of relative prosperity.

There are, of course, definite reasons for the continued growth and prosperity of this county just as there are reasons for the decline within the surrounding area.

Although it is not the purpose here to discuss at length reasons for population losses in most of southwestern Indiana, it is obvious that such factors as farm mechanization, consolidation, and abandonment, as well as increased mechanization of coal mining and a shift from deep to strip mining have played major roles. Dubois County never faced the problem of loss of mining employment, since this industry was never of major importance here. It has, however, undergone the same agricultural problems as the rest of the area.

Since physical conditions, except for mineral resources, are roughly similar over the area, something other than these must be responsible for Dubois County's exceptional qualities. This factor has been industrial development and success.

Characteristics of Dubois County Industry

Before further attempting to discuss the reasons for the exceptional industrial growth of this area, it will be of value to mention certain characteristics of Dubois County industry. The more obvious of these include:

(1) A heavy concentration of manufactural employment is found in the furniture and wood products industries. Although eleven categories of manufacturing are represented in the county, over 62% (2,694) (4) of all manufactural workers are employed in the thirty-two furniture factories. This group also includes the largest establishments. The associated and somewhat similar wood products industry is also very important in the employment picture and is represented by twenty-five establishments including two important veneer and plywood mills.

(2) Manufacturing is represented by numerous small plants rather than by one or two large ones. Although there are a total of ninety-seven factories in the county, the two largest are only in the 250-499 range.

(3) Manufacturing is not exclusively concentrated in the county seat. Although Jasper is the leading industrial center, factories of some size are also found in Huntingburg, Ferdinand, Holland, and Dubois, and small operations are carried on in other towns.

(4) The great majority of the manufacturing establishments have been developed under local ownership and by local initiative. This process has progressed to such a degree that local organizations have expanded outside the county and factories as far away as Florida, North Carolina and Pennsylvania have been founded with the use of "know how" and capital from Jasper and Huntingburg. It should be stated here, however, that local interests have not opposed the entrance of outside industry, as has been true in some Indiana cities, but have actively worked for the location of new factories within the county.

(5) Manufacturers rely heavily on truck transport. According to local spokesmen, railroad service has been, at best, only adequate, and manufacturing companies have, as a result, developed their own truck lines or have encouraged their development by others.

(6) Manufacturing in the area began as a non-union and fairly low wage operation. Associated with this, however, in most instances was a definite feeling of responsibility toward the work force and a reasonable stability of employment. At present most plants are organized, but labor troubles have been held to a minimum.

Conclusion

The development and growth of manufactural industry has been the dominant factor in the relative prosperity and economic progress of Dubois County. Physical factors, such as the original wealth of hardwood timber, agricultural products suitable for processing, a large labor pool, and nearby low-cost fuel have proved to be definitely advantageous. These advantages, however, were not confined to this county alone and, therefore, cannot be given as the reason for the county's exceptional growth as compared to its neighbors. The most important reasons for industrial growth here are human. In most cases manufactural development has been directly due to an individual or group who had the ideas, initiative, ability, and drive to start with a small shop and build it into an important industry.

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The Relation of the Changing Facies of the Mansfield[1] Formation to Possible Park Sites in Western Indiana

C. L. BIEBER, DePauw University

General

The cooperation of many groups of people, and many disciplines, are necessary in the planning for park sites in the future. Two disciplines which can work closely together in the search for small natural areas are Geology and Geography. An example of how Geology may be used to aid the Geographer or other planning experts is set forth in the following study of the Mansfield formation in western Indiana.

Over a period of several years, other geological studies involving glass-sand investigation (2) took the writer to many small recreational areas of the people in west central Indiana. A surprising number of the sites follow patterns of cliffs, steep trails, woods, springs, and caves, which are associated with the Mansfield formation (Pennsylvanian Age).

Mansfield Formation

Sampling of the Mansfield formation along the strike of the rock in west central Indiana demonstrates that facies change is a notable feature. The rock varies from chert and quartz pebble conglomerate (usually near the base) to fine-grained sandstone, siltstone, and shale. The coarser sediments including the sandstones were probably originally laid down on a plain sloping gently to the southwest (3). Broad channels carried reworked older sediments (mostly of upper and middle Mississippian age) in variable currents to resting places in and near the channels. Inter-channel areas were covered with finer silty sediments. The channel sediments were later cemented with iron oxides and compacted to form cross-bedded sandstones. The cross beds indicate water action and the direction of flow (1). The coarser-grained channel facies have resisted post Pennsylvanian weathering. These ancient channel fills now stand out as picturesquely eroded cliff-makers. As this one formation is followed for some 200 miles from west of Lafayette to the Ohio River, one notes that these sandstone hills have been used as recreation sites since the settlement of the land in the last century. Many of these areas have been visited during this study, and the rock sampled. At outcrops the sandstone may comprise all of the rock exposed, or as near the eastern margins, may overlie the Mississippian rocks in striking unconformities. The locations have been numbered and are presented on the included table 1 and map (Fig. 1).

Features

Resting on the sandstone in the northern part of the area are glacial tills. Percolating calcareous waters have cemented these gravel terraces in spotty fashion so that the terrace materials weather to odd

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[1] Made possible, in part, by a grant from the Indiana Academy of Science.

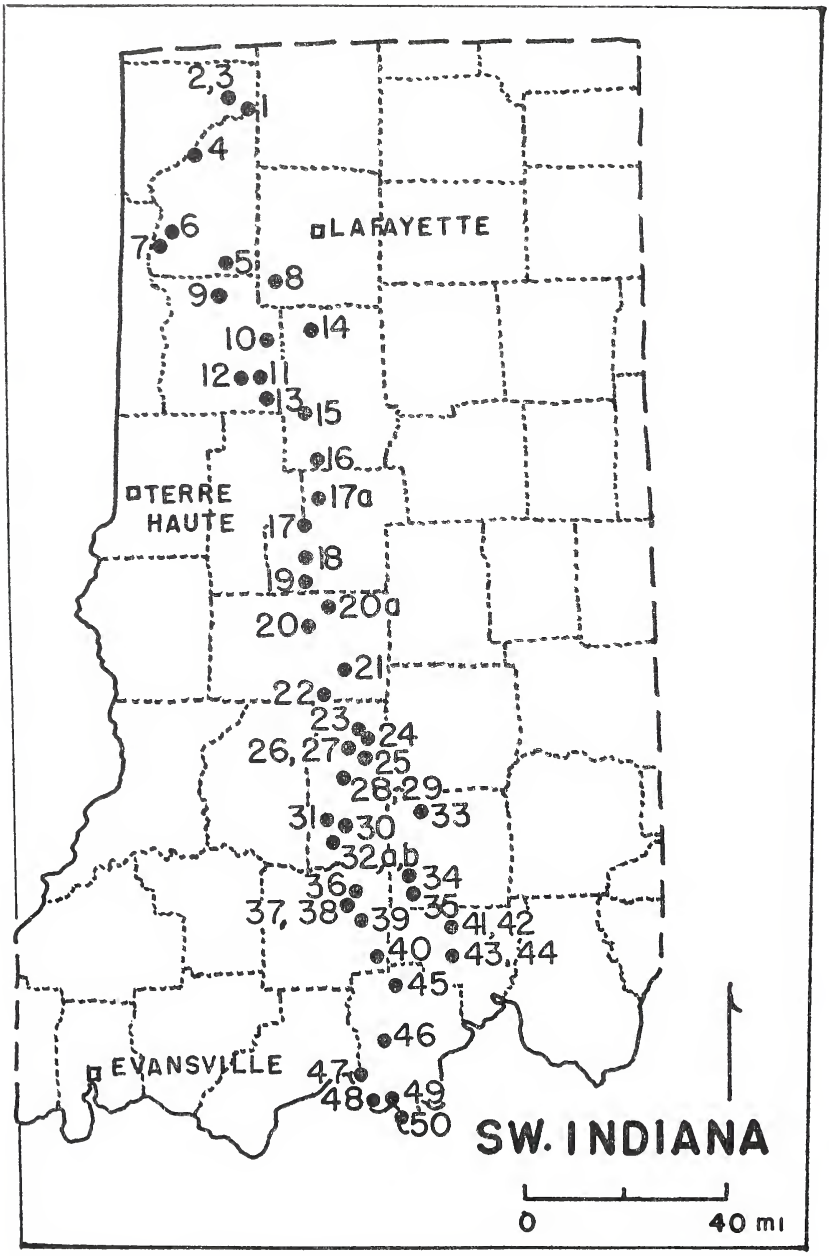
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Figure 1. Locations of areas which have been visited during the study.

TABLE 1

LOCAL (or other) NAME	LOCATION	NOTED FOR
WARREN COUNTY		
1. Black Rock	SE¼ sec.9, T.22N., R.6W	B
2. High Bridge ("Fallen Rock")	Center sec.5, T.22N., R.6W	B,T,V
3. Hanging Rock	SW¼ sec.36, T.21N., R.9W	B,V
FOUNTAIN COUNTY		
4. Portland Arch	NW¼ sec.4, T.20N., R.8W	B,A
5. Wallace	S½ sec.24, T.18N., R.6W	S
6. Coal Creek	SW¼ sec.6, T.18N., R.8W	B
7. Perrysville (East) Bluff Wabash River	W½ sec.35, T.19N., R.9W	B
PARKE COUNTY		
8. Shades	State Park	B,U,T,C,Co
9. Turkey Run	State Park	B,C
10. Hollandsburg	E½ sec.3, T.15N., R.6W W½ sec.2	B,X
11. Natural Bridge	W½ sec.33, T.16N., R.6W	A,B
12. Mansfield (Dam & Old Quarry)	NW¼ sec.8, T.14N., R.6W	J,B,Co
13. "Fallen Rock"	SE¼ sec.22, T.14N., R.6W	B,C
PUTNAM COUNTY		
14. Fincastle	N½ sec.25, T.16N., R.SW	B,V,Co
15. Fern Cliffs	Center sec.33, T.14N., R.5W	B,C
16. Hoosier Highlands	NE¼ sec.14, T.5W, R.12N	B,C,U
OWEN COUNTY		
17. Hubble Cliff	W½ sec.35, T.11N., R.5W	C
17a. Jordon	SW¼ sec.7, T.11N., R.5W	B,X
18. Stahl Farm	SE¼ sec.35, T.10N., R.5W	C,P
19. Southwest Owen Co.	N½ sec.33, T.9N., R.5W	B,X
GREENE COUNTY		
20. Gandy Bluffs	NW¼ sec.3, T.7N., R.5W	B
20a. LemleyBluffs	NE¼ sec.7, T.8N., R.4W	B
21. Ledgewood	SW¼ sec.5, T.6N., R.4W	B,C
22. Alum Cave	S½ sec.31, T.6N., R.4W	B,Cv
MARTIN COUNTY		
23. Indian Springs	N½ sec. 8, T.4N., R.3W	B
24. Tempy Hill	SE¼ sec.9, T.4N., R.3W	B
25. Raven Cliffs	NW¼ sec.15, T.4N., R.3W	B
26. Bear Hill	S½ sec.16, T.4N., R.3W	B
27. Trinity Springs	NW¼ sec.28, T.4N., R.3W	S
28. McBride Bluff	SE¼ sec.31, SW¼ sec.32, T.3N., R.3W	B
29. Choals—N. and W. of City	sec.24,25, T.3N., R.4W	B,C,E,Cv

LOCAL (or other) NAME	LOCATION	NOTED FOR
30. Spout Springs	S½ sec.25, T.3N., R.4W	S,B
31. Callahan Bluffs	SW¼ sec.26, T.3N., R.4W	B
32. Hindostan Falls	W½ sec.10, T.2N., R.4W	J,F,X
32a. Hindostan east	NW½NE¼ sec.11, T.2N., R.4W	B,X
32b. Graveyard Cliffs	SW¼ sec.34, T.2N., R.4W	B
ORANGE COUNTY		
33. Grindstone (Hopper Quarry) area	SW¼ sec.24, T.3N., R.2W	Fo
34. Drake's Cliff	NE¼ sec.32, T.1N., R.2W	B,U
35. Sutton Cliffs	SW¼ sec.32, T.1N., R.2W	B
DUBOIS COUNTY		
36. Arch Rock & Straight Rock	SE¼ sec.8, T.1S., R.3W	B
37. Raven Rock	NE¼ sec.17, T.1S., R.3W	B,Cv
38. High Rock	NW¼ sec.16, T.1S., R.3W	B,C
39. Indian Kitchen Rock	W½ sec.26, T.1S., R.3W	B,C
40. Nate Waddell Cave	NE¼ sec.35, T.2S., R.3W	B,Cv
CRAWFORD COUNTY		
41. Taswell	SE¼ sec.18, T.2S., R.1W	B,C
42. Ivory Falls	NW¼ sec.30, T.2S., R.1W	
43. Mesmore Cliffs	NW¼ sec.4, T.3S., R.1W	B
44. Fodder Cave	Center sec.4, T.3S., R.1W	B,Cv
PERRY COUNTY		
45. Peter's Cave	Center sec.6, T.4S., R.2W	B,Cv
46. Cat Rocks	SE¼ sec.36, T.5S., R.3W	B
47. Troy	S½ sec.18, T.6S., R.3W	B
48. Lupp's Cave	SW¼ sec.10, T.7S., R.3W	B,C
49. Lafayette Spring	S½ sec.12, T.7S., R.3W	B,S
50. Becker Farm	SE¼ sec.8, T.7S., R.2W	B

A	arch
B	bluffs
C	canyons
Cv	cave
Co	conglomerate
E	erosion remnants
F	falls
Fo	fossils
J	joint pattern
P	potholes
S	spring
T	travertine
U	unconformity
X	cross beds

shapes. The cemented gravels and travertine overlying the Mansfield formation are features found from the vicinity of Lafayette southward to Owen County.

Springs issuing from the sandstone are common. Some well-known springs are those one half of a mile west of Wallace in Fountain County, Spout Spring one mile south of Shoals, and Lafayette Spring on the north bluff of the Ohio River south of Cannelton. Basal conglomerates are locally common in the northern outcrops, while quartz pebble conglomerate is quarried for gravel in Martin County. Chert pebbles in the conglomerate carry Mississippian fossils in northern areas.

Caves are present, but are not long or winding. Openings are spectacular as they erode in the massive sands where variable cementation and grain combine. Caves represent differential weathering along joint sets. Examples may be seen one mile north of Shoals in Martin County.

Arches are rare, but a few have developed by unusual stream erosion along joints in cross-bedded facies. Portland Arch in Fountain County is such an example. A small but spectacular arch in Parke County was destroyed by quarrying about 1955. Other cave-like openings will probably be arches in the geological future.

Rugged cliffs and canyons are probably most characteristic of the eroded channel facies of the Mansfield formation. These are features admired by many people who live in these areas. Paths lead over these hills and valleys made by several generations of citizens who enjoy the woodlands associated with these natural features. Turkey Run State Park is an example of such an area. Many more smaller sites with similar characteristics are located along the strike of the Mansfield formation.

Erosion forms and remnants are striking. Jug Rock in the western limits of Shoals is one of these. Hindostan Falls is an example of stream erosion along a joint pattern in resistant crossbedded sandstone.

Plant fossils are common. Well preserved logs and stumps are in the "whetstone" facies north of French Lick, as well as in other scattered areas. At least one of the best of these locations should be preserved.

Possible Future Sites

Samples were taken and sections measured at all conspicuous sandstone cliffs. Special note was taken of sites most commonly used as recreation areas by the local people. By following one formation along the strike, a series of plausible recreation areas can be mapped across the state. It is especially important to the education of youth, as well as for the well-being of adults, that many small natural areas (which are often of little economic worth) be located, and eventually preserved. With federal and state cooperation, it is here suggested that local schools lead out in efforts to preserve and provide small nature-study and recreation sites for the future generations of the smaller political units.

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Alluviated Cave Springs of South-Central Indiana[1]

RICHARD L. POWELL, Indiana Geological Survey

Indiana's largest springs are classified as karst springs (Fig. 1). Karst springs are springs in limestone regions that serve as outlets for underground streams flowing in open cavities created by solution of the limestone bedrock. Most of the karst springs of Indiana, including eight of the 15 largest, are simple gravity-flow tubular or cave springs. Precipitation that enters underground passages through sinkholes and swallowholes at termini of sinking streams flows through solution channels or cavern passages and emerges elsewhere at the surface. Donaldson's Cave in Spring Mill State Park and Boone's Cave in Owen County are examples.

The remaining seven largest karst springs in the State are artesian springs or rises; the water emerging from them is forced upward from underground passages to the surface. These artesian springs are actually alluviated cave springs—cave springs that have been buried by accumulations of alluvial sediment in a previously deeper valley. At some springs the valley fill is shallow, as at the Orangeville Rise and the rise of Lost River; at others, as at Blue Spring on Big Indian Creek in Harrison County, it is thick.

In contrast to cave springs, which flow by gravity, alluviated cave springs are characterized by well-like openings through which subterranean waters from cavern passages ascend under hydrostatic pressure. Harrison Spring, 1 mile north of White Cloud in Harrison County, is the largest alluviated cave spring in Indiana (Fig. 2). It consists of a subcircular pool about 80 feet wide and 110 feet long in the bed of an abandoned meander loop of Blue River. The depth of the pool ranges from a few feet at the base of the steep sides to 35 or 40 feet at the bottom of the well-like opening or rise pit. Skin divers recently descended to this level, where they discovered a horizontal passage in limestone. A low rim or levee, apparently consisting of clays and silts, surrounds the spring on all sides except at the outlet. The outlet stream follows the bed of the abandoned meander to its junction with Blue River half a mile southwest of the spring. Although the stream flows within the flood plain, the alluvial sediments are thin in several places, and limestone bedrock is exposed in the stream bed immediately downstream from the rise—indications of a lateral-planation bench between the bedrock valley and the present valley wall (Fig. 3).

The great flow of Harrison Spring indicates that it is fed by an extensive cavern system. The minimum flow of Harrison Spring in the summer of 1960 was 27.5 cfs, measured at a time when the water was clear, but the spring often gives forth with a violent muddy discharge that partly covers the adjacent flood plain. Much of the water issuing from the spring is derived from a karst plain to the

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[1] Published with permission of the State Geologist, Indiana Department of Conservation, Geological Survey.

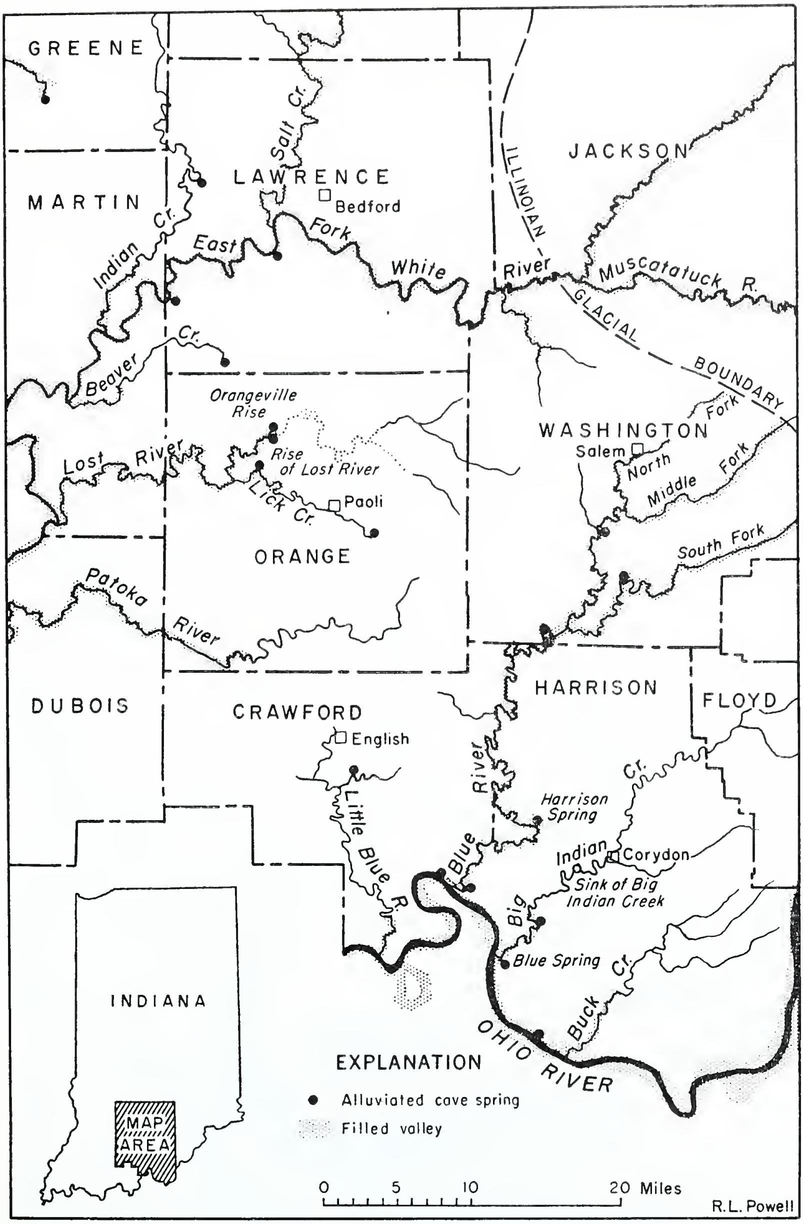

GREENE
MARTIN
LAWRENCE
Bedford
Salt Cr.
Indian Cr.
East Fork White River
JACKSON
ILLINOIAN GLACIAL BOUNDARY
Muscatatuck R.
Beaver Cr.
Orangeville Rise
Lost River
Rise of Lost River
Lick Cr.
Paoli
ORANGE
WASHINGTON
Salem
North Fork
Middle Fork
South Fork
Patoka River
DUBOIS
CRAWFORD
HARRISON
FLOYD
English
Little Blue R.
Blue River
Harrison Spring
Indian Cr.
Corydon
Sink of Big Indian Creek
Big
Blue Spring
Buck Cr.
OHIO RIVER
INDIANA
MAP AREA
EXPLANATION
● Alluviated cave spring
Filled valley
0 5 10 20 Miles
R.L. Powell

Figure 1. Map of south-central Indiana showing the location of alluviated cave springs.

north, north-east, and east. The exact extent of the underground drainage basin cannot be determined, at least not by examination of the topography. The extent of the drainage basin could be delimited

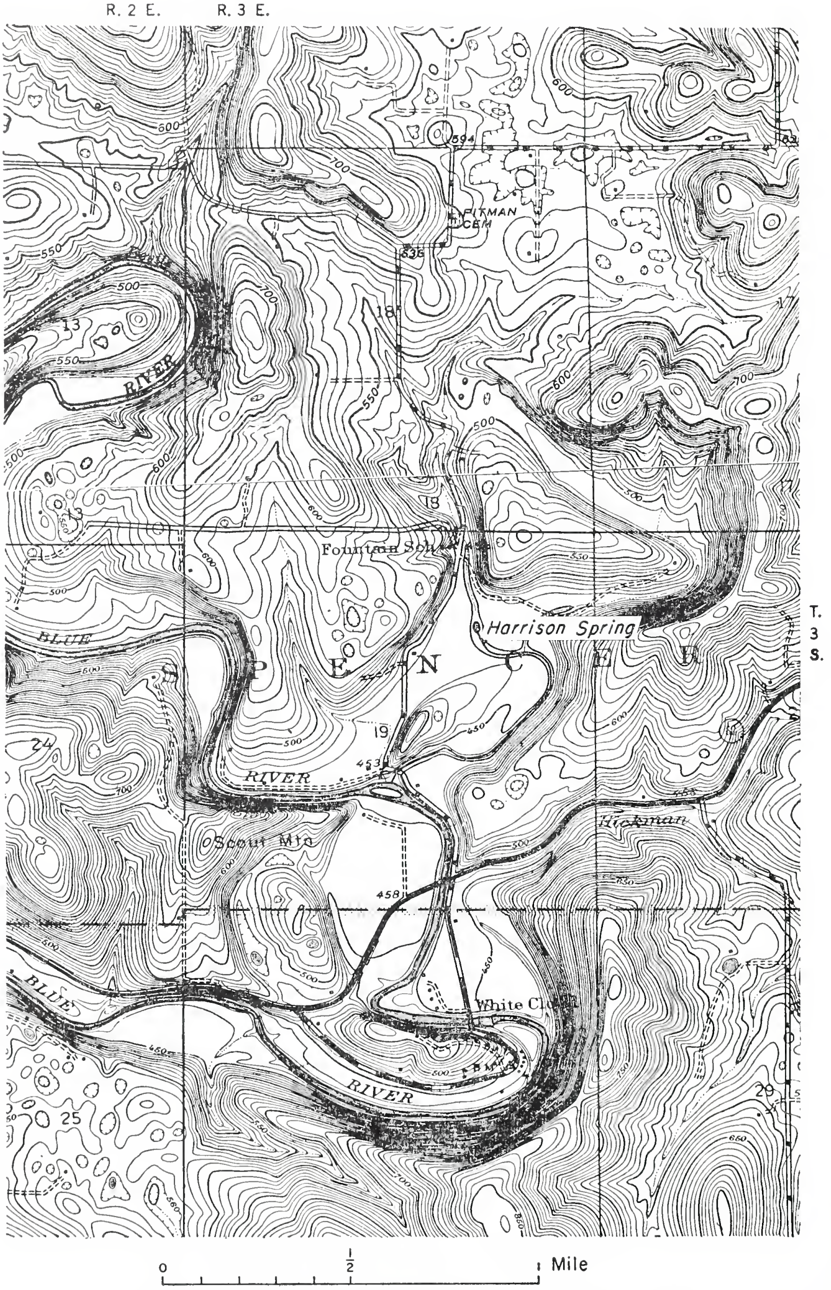

R. 2 E.
R. 3 E.
T. 3 S.
Harrison Spring
Fountain Sch
PITMAN CEM
Scout Mtn
White Cloud
BLUE
RIVER
Hickman
S P E N C E R
13
18
19
24
25
29
17
594
536
453
458
0
½
1 Mile

Figure 2. Topographic map of Harrison Spring and vicinity, Harrison County (parts of Corydon West and Depauw Quadrangles).

by the use of dyes or radioactive tracers, but this method would be expensive. The discharge at the spring may be augmented by water diverted from Big Indian Creek (Fig. 1), which sinks at a higher elevation and updip from Harrison Spring.

Harrison Spring, as well as perhaps most other alluviated cave springs, was formed at the place where a former meander of the stream swings in an updip direction and most deeply dissects the strata. Pohl (7) observed that resurgences of subterranean drainage "are found where the meanders of a surface stream are convex in an updip direction." Harrison Spring occupies a meander that crosses the axis of a broad shallow syncline, which covers an area of more than 25 square miles between the spring and Big Indian Creek (5). The sink of Big Indian Creek (NW¼NE¼ sec.3, T.4S., R.3E.), mentioned by Ashley and Kindle (1), lies updip from Harrison Spring. The hypothetical gradient between this sink and Harrison Spring would be approximately 21 feet per mile, or adequate to permit subsurface drainage from the sink to Harrison Spring. The spring described by Ashley and Kindle as the rise of Indian Creek (Stoner Spring, SE¼SE¼ sec.19, T.4S., R.3E.) was not flowing at a time when the low flow of Big Indian Creek was entering the sink. If Big Indian Creek upstream from the sink is tributary to Harrison Spring, part of the waters of more than 200 square miles could be added to the drainage area of Harrison Spring (Fig. 4).

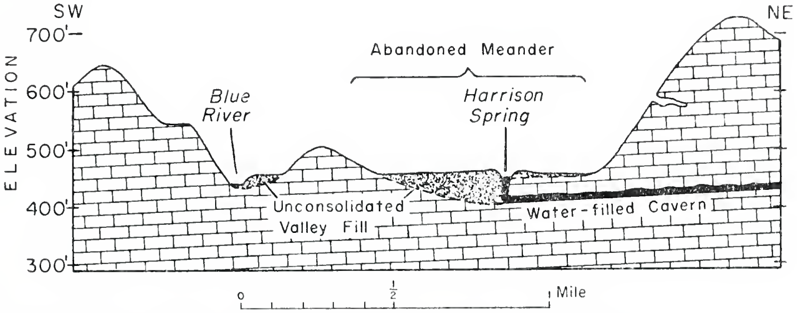


Figure 3. Idealized cross section through Harrison Spring and Blue River.

The second and third largest springs in Indiana are the Orangeville Rise and the rise of Lost River (Fig. 1). These two karst springs are the resurgences of subsurface drainage in Lawrence, Orange, and Washington Counties, which has been described by Malott (4) (Fig. 4). The Orangeville Rise, which is fed by some 30 square miles of drainage north and northeast of Orangeville, is on the south side of Orangeville at the head of perennial Lost River (Fig. 5). It is the more picturesque of the two rises and has long been mistakenly considered by many local people to be the rise of Lost River.

Malott (4) stated:

> The Orangeville rise issues from a semicircular rock-walled pit 110 feet across, and the waters rising from it flow southward in a

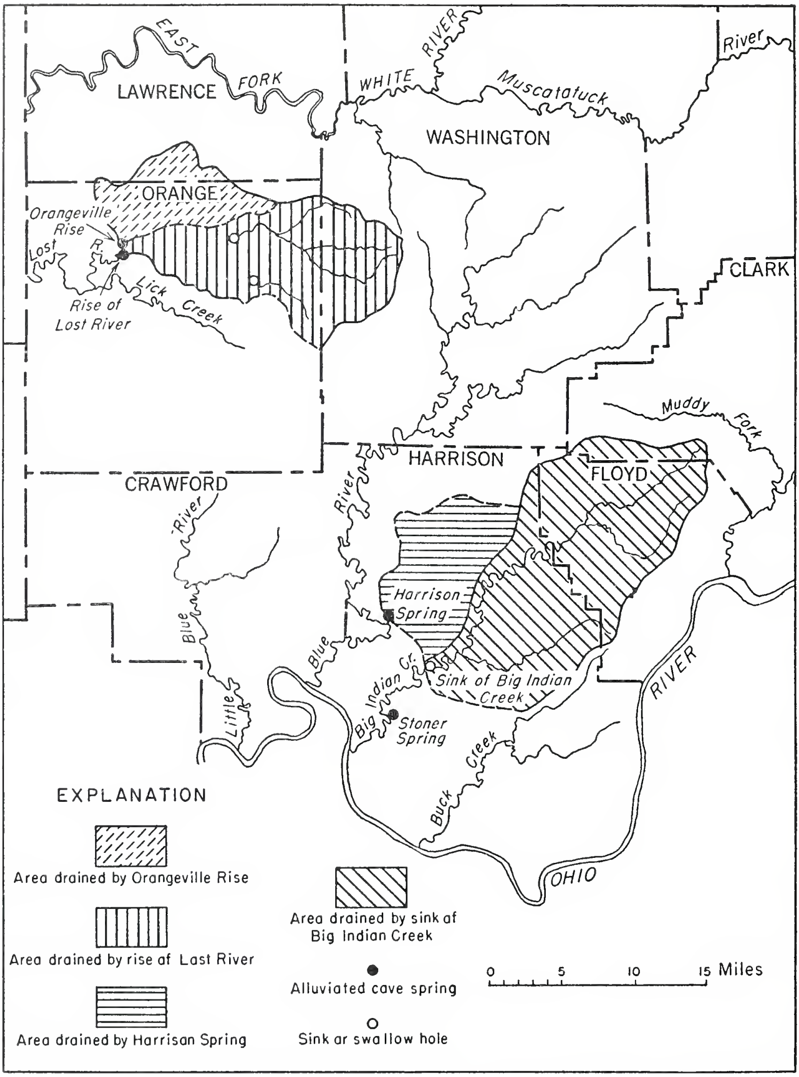
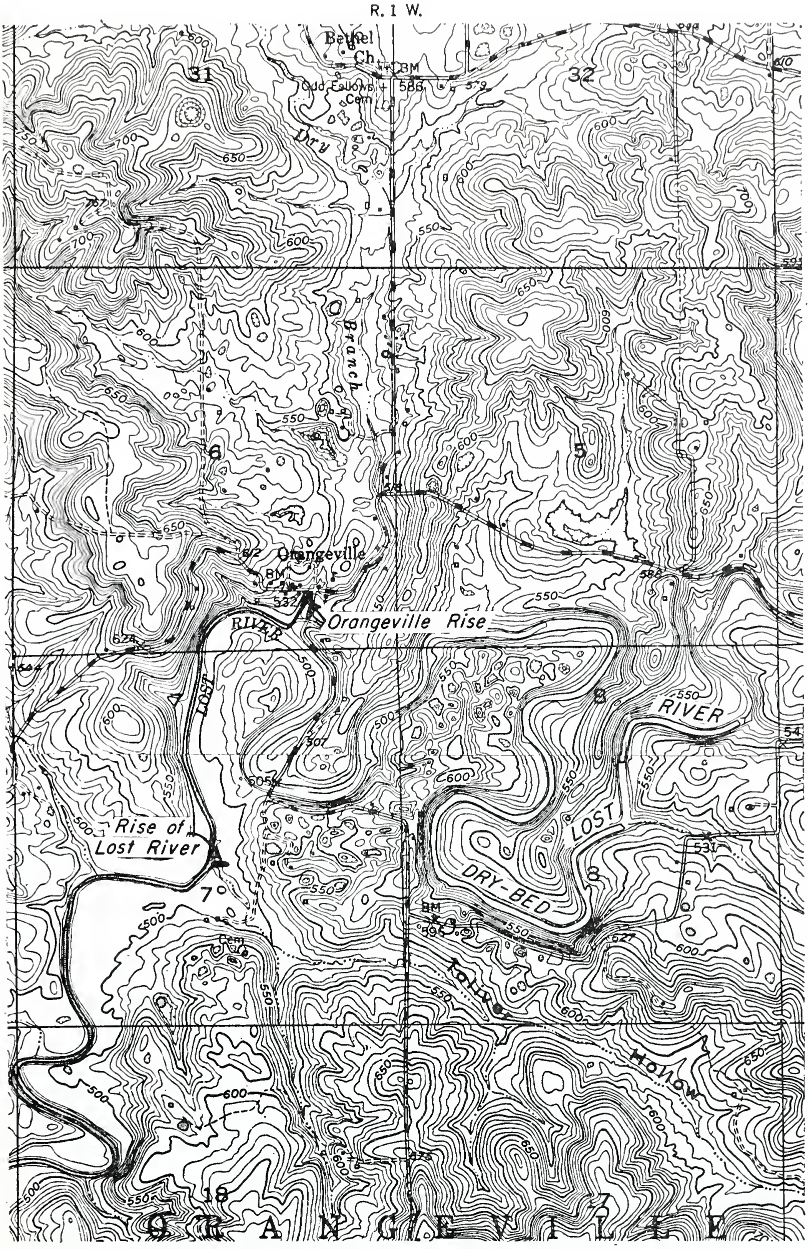

EAST FORK
LAWRENCE
WHITE RIVER
Muscatatuck
River
WASHINGTON
ORANGE
Orangeville Rise
Lost R.
Lick Creek
Rise of Lost River
CLARK
Muddy Fork
HARRISON
FLOYD
CRAWFORD
River
Blue
River
Harrison Spring
Blue
Big Indian Cr.
Sink of Big Indian Creek
Stoner Spring
Little
Buck Creek
RIVER
OHIO
EXPLANATION
Area drained by Orangeville Rise
Area drained by rise of Lost River
Area drained by Harrison Spring
Area drained by sink of Big Indian Creek
Alluviated cave spring
Sink or swallow hole
0 5 10 15 Miles

Figure 4. Map showing the areas drained by Harrison Spring, sink of Big Indian Creek, Orangeville Rise, and rise of Lost River.

mud-banked channel 15 feet deep and 40 to 50 feet in width for about 150 yards before entering Lost River. The waters rise some 15 or 20 feet as a great artesian spring from a water filled cavern the mouth of which is apparently 70 feet in width. The rock wall above the waters . . . form an overhanging, lunar-shaped cliff about 15 feet above the waters in the rise pit. . . . After heavy rains its flow is estimated to reach or exceed 2,000 cubic feet per second, and its lunar shaped, low cliff is submerged and the channel leading to Lost River is filled to overflowing.


R. 1 W.
T. 3 N.
T. 2 N.
Bethel Ch.
Odd Fellows Cem.
BM 586
Dry Branch
31
32
6
5
8
7
18
Orangeville
Orangeville Rise
Rise of Lost River
LOST RIVER
DRY-BED LOST RIVER
Tolliver Hollow
Cem
BM 595
ORANGEVILLE

0 1/2 1 Mile

Figure 5. Topographic map of the Orangeville Rise and the rise of Lost River and vicinity, Orange County (parts of the French Lick and Georgia Quadrangles).

If the alluvial fill were removed, the buried cave spring at Orangeville would resemble the entrance to Boone's Cave in Owen County.

The rise of Lost River, which marks the resurgence of more than 80 square miles of surface drainage that has been diverted underground, lies about three quarters of a mile southwest of Orangeville (Fig. 4). It consists of several openings of small diameter that are aligned in the floor of a steep-banked channel, which is about 25 feet deep, and which is filled with water to a maximum depth of 11 feet at low-water stage. A sounding in one of the rise pits indicated that the cavernous route which feeds the resurgence is at least 17 feet below the floor of the channel. The channel enters Lost River within 50 feet of a rise pit. The stream from the Orangeville Rise is only a few feet deep, but downstream from the rise of Lost River the water reaches depths several times greater than those upstream from the junction.

The Orangeville Rise and the rise of Lost River are alluviated cave springs. The present channel immediately downstream from the Orangeville Rise does not reach bedrock, but farther downstream the channel crosses a buried bedrock bench. The rise of Lost River lies in a flat part of the valley, and no bedrock is exposed either at the rise or in close proximity to it. The cavernous routes and their exits into the buried bedrock valley lies 30 to 50 feet below the top of the present valley fill.

Indiana's alluviated cave springs are found along major streams that are tributary to the Ohio River and the East Fork White River. The valleys of both of these streams are known to contain deep bedrock channels. The U. S. Corps of Engineers discovered bedrock approximately 270 feet above sea level or 114 feet below the normal pool elevation of the Ohio River about 1 mile upstream from Blue River.

The headwaters of Blue River lie in northeastern Washington County at a general elevation of 800 feet above sea level. The gradient of the buried bedrock valley between the headwaters and Harrison Spring is about 5½ feet per mile. The Illinoian ice sheet overrode the Knobstone Escarpment in northeastern Washington County, and meltwater streams deposited as much as 50 feet of outwash, silts, clays, sands, and gravels in the three forks of Blue River (Fig. 1). These deposits are preserved as terraces and valley fill (9). The lower part of Blue River, probably as far upstream as Harrison Spring, was the site of a Wisconsin-age lake. The lacustrine materials filled the valley to an elevation of 435 feet near the mouth of Blue River (9), and at Harrison Spring stream-borne silts and clays stand at an elevation of 455 feet.

The cavern outlet of Harrison Spring lies at least 35 or 40 feet below the surface of the spring or about 405 feet above sea level. The gradient of the buried bedrock valley between Harrison Spring and the Ohio River has been calculated at just more than 7 feet per mile, but that of the Ohio bedrock valley is less than a foot per mile. It is likely that the bedrock valley of Blue River in its lower reaches is at grade with the Ohio and that the waters of Harrison Spring may rise from a passage that is at a depth greater than 40 feet.

Various karst hydrographers such as Swinnerton (8), Piper (6), Gardner (2), and Malott (3 and 4) have indicated that caverns are formed at or near the water table or base level by the diversion of surface water or by the sapping of ground water from carbonate uplands adjacent to deeply dissected valleys through subterranean routes. Because most artesian karst springs are found along deeply filled bedrock valleys of pre-Kansan age, it logically follows that they are buried cave springs that predate the filling of the valleys, which took place during Kansan, Illinoian, and Wisconsin time.

Thus the cavern that feeds Harrison Spring was formed at grade with base level of a deep stage during early Pleistocene time. The large volume of water emerging at this level may account for the steepened bedrock profile of Blue River below the spring, but the spring may rise from a slightly lower elevation, which would also decrease the gradient. Tucker (10) estimated that 25 percent of the discharge of Blue River at White Cloud originates at Harrison Spring. The cavern system that is tributary to the spring must have been formed prior to Illinoian time when the headwaters of Blue River were encroaching into northeastern Washington County. Later, Blue River was partly filled with Illinoian outwash, and later yet the spring may have received a cover of backwater lacustrine deposits of Wisconsin age.

The rise may have originated suddenly as hydrostatic pressure forced trapped subterranean waters to ascend through the sediments that impounded the former cave spring. A more logical, although less dramatic, explanation is that the water welling up from the cavern prevented deposition within the area above the cave spring while alluvial or lacustrine deposits were filling the rest of the valley. Sediment settling within the mouth of the submerged cave spring was carried upward by the ascending water and was deposited at the margin of the opening where current slackened, in somewhat the same way as a natural levee is formed. Natural levees are formed around some rise pits, especially those situated well within flood plains.

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Manufactural Geography of Hammond, Indiana
(A Study in Geographic Anomaly)

Alfred H. Meyer and Nora Mitchell, Valparaiso University

This seminar study in "Geographic Problems," together with those already published in the *Proceedings* on northwest Indiana-northeast Illinois communities (LaPorte, Michigan City, Gary, East Chicago-Whiting, and Chicago Heights), is designed to portray comparatively the geographic processes operative in the establishment of industrial patterns of a region—the Calumet. The ultimate objective, upon completion of such studies, is to view all these communities in a unified regional perspective, since for the most part they together focus on Chicago metropolitanism. Meanwhile, Calumet corporate entities invite separate preliminary geographic treatments, if for no other reason than to determine how the several political structures function in relation to the local and regional natural and human resources, and to one another.

Questionnaire, interview, and field inventory of Hammond (Pop. 111,698) gives impression of a strong industrial community (over 100 establishments), with dedicated civic leadership, and a citizenry alert to the needs of maintaining and upgrading residential standards in a region with marked tendencies towards residential blight. A geographic appraisal of Hammond reveals that it shares the problems of communities which have come only belatedly under the influence of systematic and co-ordinated geographic planning. As a result, certain geographic "anomalies" (variances from general geographic principles) are identified with the area:

1. Prorupted "L" figure disunifies urban and regional functions. Moreover, the northerly extended arm of the "L" with its own added stricture provides a scant 2 miles of Lake Michigan frontage out of a total city periphery of 25 miles. Even this negligible shoreline, as historical check reveals, was begrudgingly bestowed as a result of corporate fragmentation of neighborhood community organization.

2. Physical geography "decreed" a long time ago the establishment of a harbor and port for this community, the largest industrial Indiana city on Lake Michigan, next to Gary. By contrast, with no industry at all, when first proposed, a public deep-water harbor-port was projected at the Indiana Dunes Burns Ditch site about twenty-two miles to the east.

3. Next, a geography crystal gazer in the latter part of the nineteenth century, looking at the riverine pattern of the Grand Calumet and the Little Calumet, and its juncture with Lake Michigan to the north, and with the Illinois River to the west via the Cal-Sag, would have prognosticated some navigable waterway for Hammond on one or both of the Calumet rivers. Notwithstanding farsighted and energetic efforts at such development, a navigable waterway still remains an unrealized geographic vision.

4. The greatest convergence of rails in Indiana is to be found in Hammond. Normally such betokens a superior geographic pattern of

rail transportation, providing effective circulation into and out of metropolitan Chicago as well as facile regional connections with markets far afield. But such a tightly woven rail net can and does in the Hammond situation create one of the worst grade-crossing traffic tie-ups in the country. This reportedly constitutes a major obstacle to attracting new industries, as more and more industries switch to motor transport.

5. Comparing the combined strategic values of geographic site on the head of Lake Michigan with the regional position as respects northwest Indiana as part of metropolitan Chicago, and sharing with its prominent industrial Indiana neighbors leadership in the production of primary world products, we would have expected an early development of sound geographic perspective and its embodiment in a unified plan capable of realizing Hammond's full geographic potential. But despite numerous aggressive organizational attacks through the years to promote the industrial-residential climate of the community, it was not until 1951 that a master plan was perfected. Even now there is evidence of the need for a more unified attack on the city's industrial problems by Hammond's own multiple civic and political organizations as well as a concerted effort by it and the other Indiana-Illinois Lake Michigan communities for inter-city, inter-county, and inter-state planning, if harmonious Nature-Man goals are to be attained.

It is the purpose of this paper to examine and evaluate the industrial complex of Hammond, an "artificial" political area with a functionless Great Lakes frontage on the north, a restrictive state-line boundary on the west, boundary-pressing heavily-industrialized corporate entities on the west (Chicago, Calumet City), on the east (Whiting, East Chicago, Gary), and suburban Munster and Highland on the south.

Early Environs and Occupance of Hammond

The growth and development of important industrial cities can often be traced to their favorable physical environment. However, the original physiography of Hammond cannot be described as particularly favorable (Fig. 1).

Hammond developed industrially only after Chicago had already become populated and land prices in this less attractive Calumet Region to the east were cheap enough to counteract the inconveniences of living in such a place. The reason for this cheaper land-availability, which was reported as a decisive locative factor by 25 percent of the present-day industrial concerns, is related in great measure to its glaciated structure. The retreat of the ice sheet from the Calumet area (the old Lake Chicago basin) left a series of badly drained interdunal marshes in its wake. As late as 1870, when there had been an industrial settlement for twenty years at Hammond, it was still not possible to walk through the marshy underbrush from the settlement to the Michigan Railroad station at Whiting, five miles away.

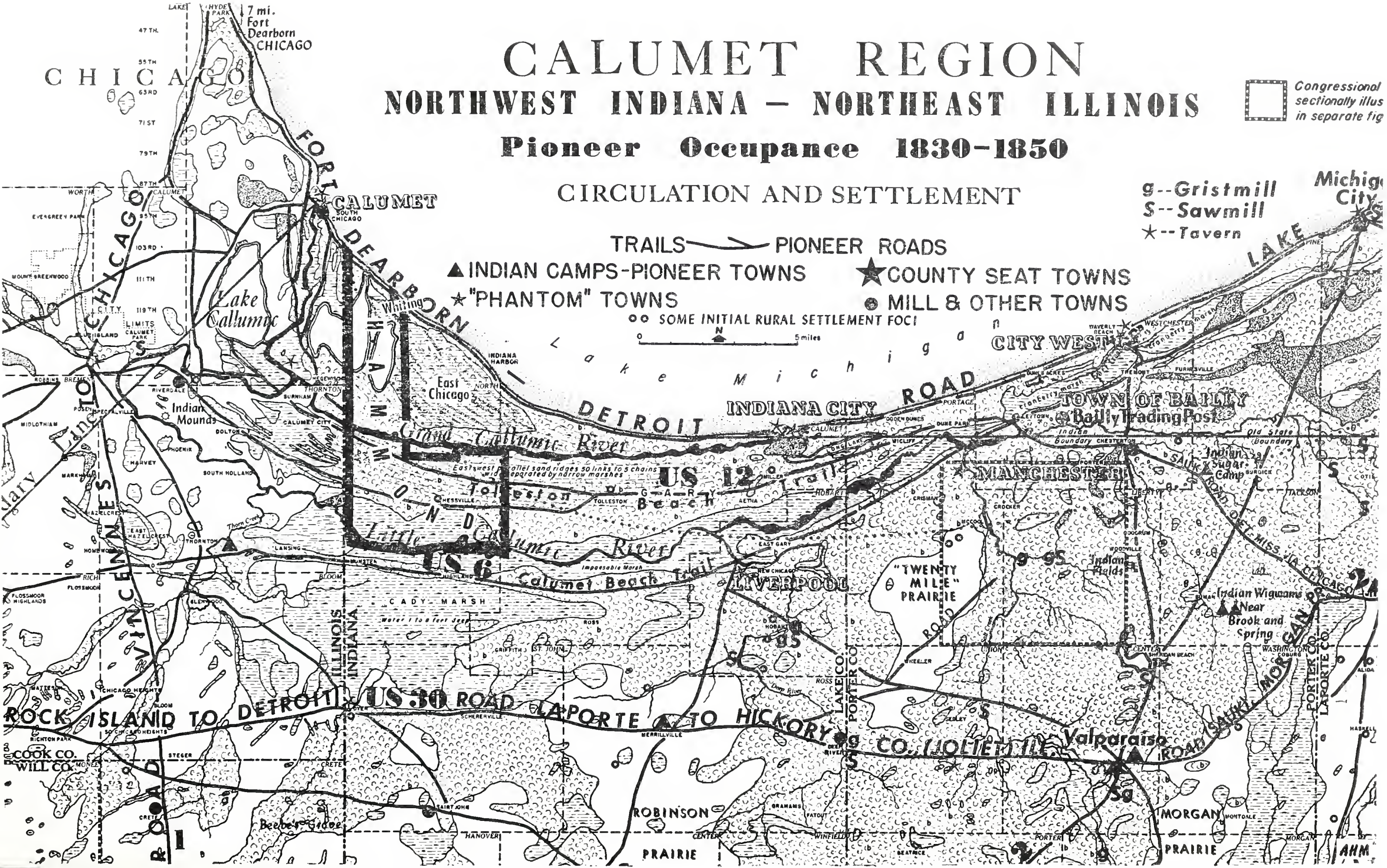
Though inhospitable, the marsh and woodlands of the Calumet Region had some settlements and formed important crossroads in

CALUMET REGION

NORTHWEST INDIANA – NORTHEAST ILLINOIS

Pioneer Occupance 1830–1850

CIRCULATION AND SETTLEMENT


TRAILS → PIONEER ROADS
▲ INDIAN CAMPS-PIONEER TOWNS
★ COUNTY SEAT TOWNS
☆ "PHANTOM" TOWNS
● MILL & OTHER TOWNS
○○ SOME INITIAL RURAL SETTLEMENT FOCI
0 5 miles
N
g--Gristmill
S--Sawmill
☆--Tavern
Congressional sectionally illus in separate fig
CHICAGO
7 mi. Fort Dearborn CHICAGO
FORT CALUMET
SOUTH CHICAGO
FORT DEARBORN ROAD
DETROIT ROAD
CHICAGO TO VINCENNES
ROCK ISLAND TO DETROIT US 30 ROAD
LAPORTE TO HICKORY CO. (JOLIET) ILL.
SAUK ROAD
SAUK ROAD OF MISS. TO CHICAGO
Lake Michigan
LAKE
Lake Callumic
Grand Callumic River
Little Calumet River
HAMMOND
GARY
Tolleston Beach
Calumet Beach Trail
US 12
US 6
US 30
CADY MARSH
Whiting
East Chicago
INDIANA HARBOR
INDIANA CITY
CITY WEST
TOWN OF BAILLY
Bailly Trading Post
MANCHESTER
LIVERPOOL
Valparaiso
Michigan City
"TWENTY MILE" PRAIRIE
Indian Mounds
Indian Sugar Camp
Indian Fields
Indian Wigwams
Near Brook and Spring
Indian Boundary
Old State Boundary
ILLINOIS
INDIANA
COOK CO.
WILL CO.
LAKE CO.
PORTER CO.
LAPORTE CO.
ROBINSON
PRAIRIE
MORGAN
Beebe's Grove
Impassable Marsh
East-west parallel sand ridges 50 links to 5 chains wide separated by narrow marshes
Water 1 to 4 feet deep
Thorn Creek
Deep River
AHM

North America since people inhabited the continent. The most popular Indian route was the Lake Shore Trail, which passed through the northern part of present-day Hammond (Fig. 1). Several other Indian trails also passed directly through what is now central Hammond. The Grand Calumet River was an important Indian thoroughfare. Fur-bearing animals were native to this region, and, together with fish, supplied an important part of the diet of both settlers and hunters. The animals were also the attraction for French trappers when this area became a French colony. Fur-trading posts were erected and the old routes became increasingly important and well established. The routes took on new significance during the battles and maneuvers in the uneasy times when the Calumet was part of the British Empire.

The first American settler in Hammond took advantage of the strategic position of road and river confluence. In 1875 the town of Hammond was platted and eight years later it became an incorporated community. By 1865 four railroads had crossed the Calumet Region to line up eastern and southern states via Chicago. By 1890 the population had grown to almost 5,500 inhabitants.

With the railroads came a distinct improvement in standards of living. In the large eastern communities people were able to purchase meat from the midwestern cornbelt when local supplies became insufficient. Cattle were shipped hundreds of miles on the railways. However, shipping live cattle was an uneconomical business. Packers began to slaughter and pack the carcasses in ice, but carelessness in renewing ice blocks caused serious problems in this direction.

How combined circumstances of inventive ingenuity and intuitive environmental discretion can lead to fortuitous regional enterprise with an immediate national impact is epically illustrated in the discovery of transportation refrigeration, the answer to the problem of meat spoilage in transit. Our file notes on Ball, Howat, Goodspeed, Demmon, Eenigeberg, and other local historians indicate this event-environment association as the leading phenomenon of industrial pioneering in the Hammond region. As the story goes, Davis Brothers fish dealers in Detroit (1868) had perfected an ice box capable of fresh fish shipment from Lake Huron and Lake Superior to Detroit. George H. Hammond, operating a meat establishment close to the Davis market, got the idea that the same principle of refrigerated fish transportation might be applied to fresh meat transportation. Davis Brothers designed a car for this purpose built by the Michigan Car Company. With the aid of several associates, the first meat shipment was successfully dispatched during warm weather to Boston under railroad supervision.

The story now shifts to an environmental application of the idea. Where in the populous and stock-raising Midwest could a large slaughtering establishment be located which combined desirable site qualities with adequacy of natural ice supply and transportation facilities? Ready access to livestock market suggested Chicago, but Chicago residents objected to this "nuisance" industry. It was then decided to explore further east in the marshes and waste lands of the Calumet. A site was finally agreed upon, known as State Line, just west of what is now

Hohman Avenue in Hammond, serviced by the Michigan Central railroad. Here the river and neighboring slough provided an abundance of ice, harvested during the winter for all cooler and car use during the spring, summer, and fall seasons. Moreover, the Calumet River provided means of sewage disposal. Beginning in 1869, upon the moderate basis of processing 300 cattle per week, the establishment once was the largest beef-packing house in the United States, and perhaps in the world, with shipments as far east as New England and even to the markets of Europe. "Operating facilities included 200 box cars, 200 stock cars, 300 refrigerator cars and 24 ships with patented refrigerating apparatus" (Goodspeed).

Modern technology, perhaps more than anything else, effects changes in the assessment of industrial qualities of topographic site and regional situation. With the innovation of modern refrigeration systems, the geographic advantages of proximate natural-ice resources in an area of "waste" lands ceased to be operative. Moreover, as in the case earlier of Michigan City, industrial-commercial values of Lake Michigan sites, including Hammond, gravitated increasingly to the metropolitan rail and market center of the Midwest—Chicago. And so, the English syndicate that had purchased the firm following the death of George Hammond in 1886, after a disastrous fire in 1901, decided to relocate in Chicago, the city which had originally rejected the industry.

Early Development of Industry

Although Hammond is the oldest of the Calumet industrial cities, it is not the largest, nor has its growth been as spectacular as that of either the steel city, Gary, or the oil center, Whiting. Reasons for this in part may be attributed to several geographical maladjustments. The shape of the city and its constricted shoreline are handicaps. Neither the Little Calumet nor the Grand Calumet river is navigable for large lake-bound ships. Having no harbor on Lake Michigan, Hammond must use the Calumet Harbor in South Chicago, or the Indiana Harbor to the east.

In 1896, a Hammond mayor made plans to dredge a channel along the Wolf River to Wolf Lake (Figure 3). He claimed that Wolf Lake would make a safe harbor for ships even in stormy weather, and be large enough to accommodate all the shipping on the Great Lakes at that time, at a cost no greater than the upkeep of the existing harbors. Had he been able to receive the federal aid for which he applied in Washington, Hammond might well have become the steel town Gary now is.

The Calumet Harbor was developed by the federal government in 1870, and an appeal was then made that the Grand Calumet should be dredged as far as Hammond. A channel was dredged in 1888, but because of sluggish currents and the refuse and sewage dumped into the river, it soon filled up again, and dredging was shortly discontinued. When the Indiana Harbor Ship Canal was constructed early in the present century (Figure 2), it was recommended that a short ship canal should also be built to link the Grand Calumet, and thus Hammond, with it. However, as no land was forthcoming, the project was not carried out.

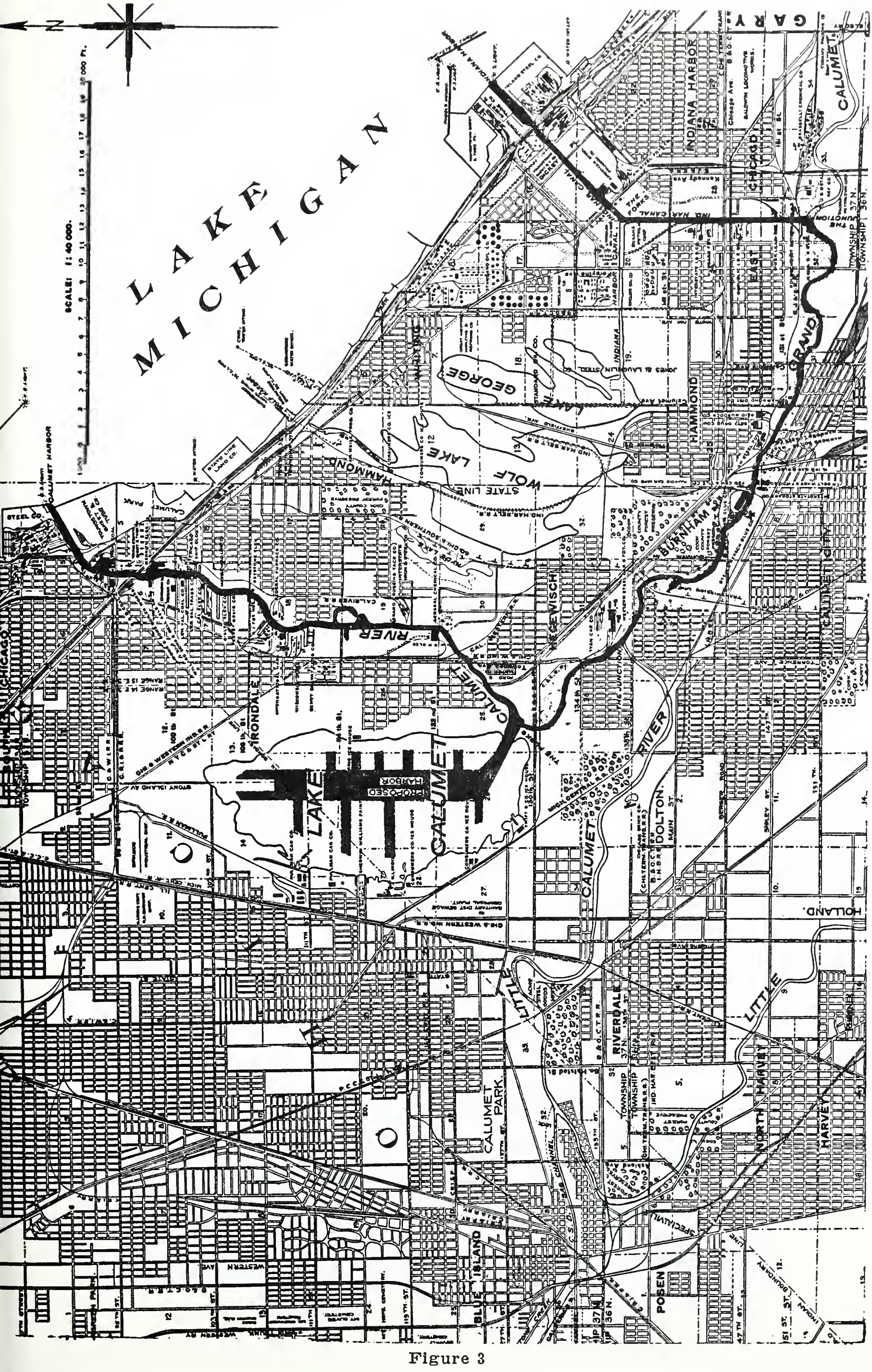

N
SCALE: 1:40 000
LAKE MICHIGAN
CALUMET HARBOR
STATE LINE LAND CO.
STEEL CO.
INDIANA HARBOR
GARY
CALUMET
EAST CHICAGO
HAMMOND
WOLF LAKE
GEORGE
STATE LINE
INDIANA
JONES & LAUGHLIN STEEL
STANDARD OIL CO.
IND. HAR. CANAL
TOWNSHIP 37 N.
TOWNSHIP 36 N.
GRAND CALUMET
BURNHAM
HEGEWISCH
CALUMET RIVER
IRONDALE
LAKE CALUMET
PROPOSED HARBOR
CALUMET CITY
SOUTH CHICAGO
RANGE 14 E.
RANGE 15 E.
STONY ISLAND AV.
PULLMAN R.R.
DOLTON
CALUMET RIVER
LITTLE CALUMET
HOLLAND
RIVERDALE
TOWNSHIP
CALUMET PARK
LITTLE
NORTH HARVEY
HARVEY
BLUE ISLAND
POSEN
WESTERN AVE.
INDIANA BOUNDARY LINE

Figure 3

Hammond took on the peculiar elbow shape in 1897. For some time the artesian water supply had been inadequate, and a waterfront on Lake Michigan was necessary. It would simplify city planning today if the shape of the city were more nearly rectangular, with a larger waterfront, but it took the civic leaders of Hammond four years of struggle with land owners to procure the less than 2-mile front along the Illinois/Indiana boundary which it has today.

Hammond and Towle, the early founders of the city of Hammond, developed the city and laid its industrial foundations. As cheap water transportation was not available, they made use of the railroads. Through their ventures, not only the meat-packing station, but also a saw mill, carpentry factory, frozen duck packing station, printers, glue and fertilizer company, wagon, carriage and spring works, corn syrup factory, nail company, a foundry, two distilleries, flour mills, and a bank were established between 1868 and 1898. Dressed meat and other exports were also sent to the eastern cities.

Two of these industries, the meat-packing company and Conkey's printing works, were really large establishments. By 1901, these two concerns between them employed nearly 3,000 workers. In October 1901, a great fire broke out and destroyed the packing plant to such an extent that work there was never resumed. In the same year there was a prolonged strike at the printing company. In the resulting depression many families moved away from Hammond. In 1902, a Hammond Industrial Committee was organized which was responsible for much of the city's industrial development for the next twenty-five years. During this time the new manufacturing establishments included a distilling company, potato-machine plant, piano factory, surgical instruments makers, railroad freight car manufacturing, two petroleum refineries, and a large soap factory (1).

Industrial Structure

Since the 1901 depression the industries of Hammond have remained diversified. There has been both an increase in the types of industries and also of growth within most of the industrial concerns. The number of employees, which in 1900 was approximately 3,000, has almost quadrupled to the present 11,500 employed workers in manufacturing establishments (2). They work in some 100 establishments. Four of these employ over 1,000 employees. The remaining companies are smaller units.

Unlike "Big Steel" Gary and "Oil Refining" Whiting, Hammond is not a one-industry dominated community, and so is not affected by wholesale "industrial shutdown" layoffs of labor as a result of a one-industry dominated strike. Diversification is reflected in the following directory categories, with the number of firms indicated parenthetically: metal products (17), chemical products (14), printing (13), steel products (12), machinists (9), food products (9), electrical equipment (6), petroleum (5), cement products (4), metal refiners (3), lumber products (3), electric power (2), paper products (2), fertilizer (2).

In terms of total classified employment in the leading industries of over the 100 employment scale, the number ranges approximately from of cartographic representation, however, with its rigorous demands on simplicity and minimum legend categories of meaningful associations, the one here exhibited in Figure 2 seems as useful as any. The "key" is an adaptation of the government's "Standard Industrial Classification Manual" (3). Its consistent use, with minor modifications to fit local geographic conditions, serves the purpose of a co-ordinate evaluation of industrial communities, as in this case of the several studies already completed in the Calumet region. Thus, comparing the industrial 8000 in petroleum down to 100 in cement products: petroleum (8038), electric power (4181), steel products (2953), chemical products (2172), metal products (1768), food products (1716), printers (1116), machinists (547), mattresses (Simmons) (500), metal refiners (436), paper products (332), electrical equipment (205), fertilizers (186), cement products (140), lumber products (118).

No one industrial classification key seems to be an all-purpose guide to industrial inventory and geographic analysis. For purpose pattern of Hammond with that of its east neighbor, East Chicago (4, Figure 4, p. 173), we observe a strong similarity in geographic composition. Fabricated metals constitute the dominant enterprise in both—34 percent in the case of Hammond; 31 percent for East Chicago. Combined chemical and petroleum products feature a second place of priority—20 and 23 percent, respectively. On the other hand, Hammond's printing and paper establishments are distinctive—18 of them; while East Chicago's "primary metals" are similarly distinctive for that community.

As then noted in Figure 2, the industrial concerns are classified and enumerated according to nine different types of manufactured products: 1) Food and Kindred Products (5); 2) Apparel and other Textile Products (2); 3) Lumber, Wood and Furniture (4); 4) Paper Products and Printing (18); 5) Petroleum and Chemicals (19); 6) Stone, Clay and Glass Products 6); 7) Fabricated Metal Products (33); 8) Electrical Machinery and Supplies (6); 9) Transportation Equipment (4). This reveals that over one-third of Hammond's total industries and almost a third of Hammond's total workers are connected with steel symbiosis, or related metal works in the Calumet Region. The statistics given by these firms in connection with the materials they use bear out the inter-relationship of these firms, especially with Gary's steel mills. No primary metals are manufactured in Hammond itself.

As noted above, the Petroleum and Chemical group is the next largest group, accounting for another 19 firms. It is noteworthy on the map that all the sites of the petroleum companies lie within the inner Hammond "elbow"; i.e., bordering on the petroleum cities of Whiting and East Chicago, and obviously connected with them. Although no petroleum is refined in Hammond itself, much space in Hammond is devoted to the storage of petroleum. All but three of the chemical works are located in the areas owned by the petroleum companies.

There are 18 printing firms or associated paper producers in Group 4. All of these are small establishments with the exception of Rand McNally, which is the original Conkey's Printing Works. Though its

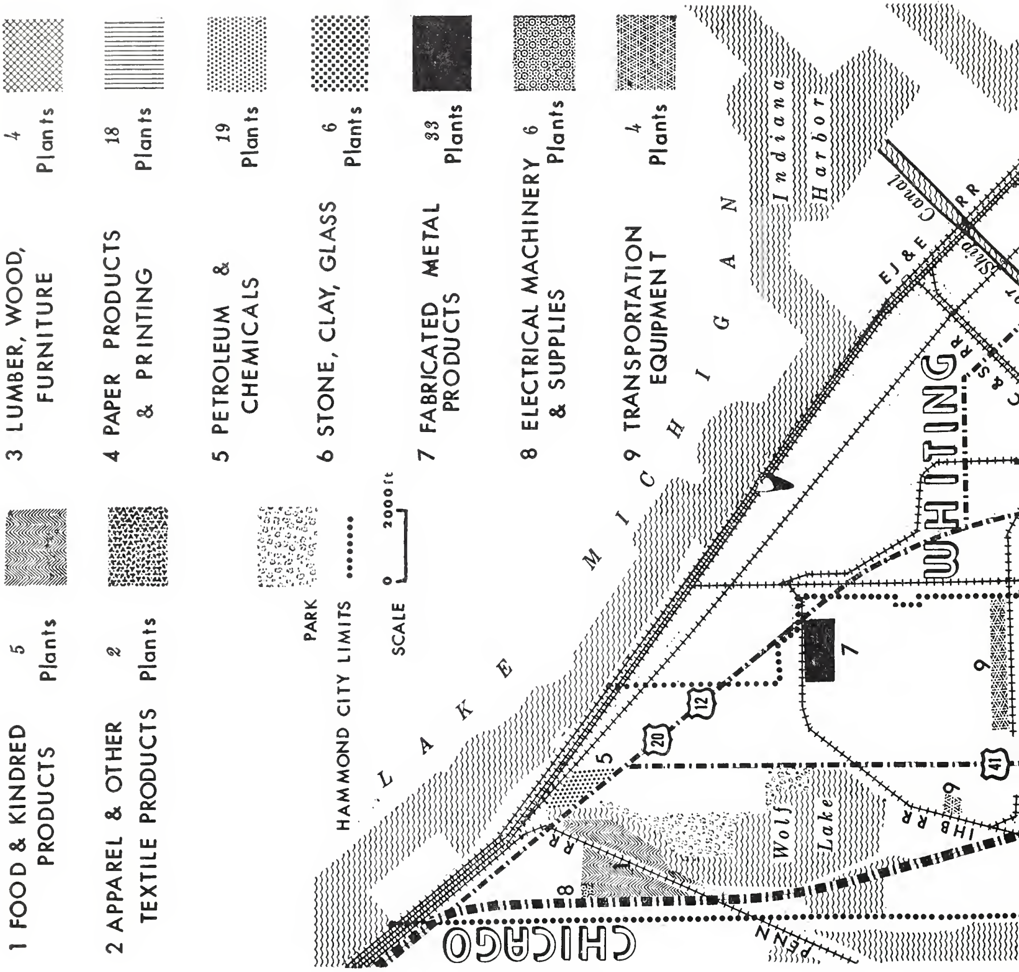

1 FOOD & KINDRED PRODUCTS 5 Plants
2 APPAREL & OTHER TEXTILE PRODUCTS 2 Plants
PARK
HAMMOND CITY LIMITS
SCALE 0 2000 ft
3 LUMBER, WOOD, FURNITURE 4 Plants
4 PAPER PRODUCTS & PRINTING 18 Plants
5 PETROLEUM & CHEMICALS 19 Plants
6 STONE, CLAY, GLASS 6 Plants
7 FABRICATED METAL PRODUCTS 33 Plants
8 ELECTRICAL MACHINERY & SUPPLIES 6 Plants
9 TRANSPORTATION EQUIPMENT 4 Plants
LAKE MICHIGAN
Indiana Harbor
Ship Canal
EJ & E RR
WHITING
CHICAGO
Wolf Lake
IHB RR
PENN
20
12
41

Figure 2

employee figure is comparatively high, it has remained almost static since 1900. All these firms are located in the busy central region of Hammond.

The three types—metal products, chemicals, and printing works—comprise 70 percent of Hammond's industries. The manufacturers of other types of goods have only between two and six plants each. The map shows the locations and size of these 97 firms according to their grouping in the nine types of manufactures.

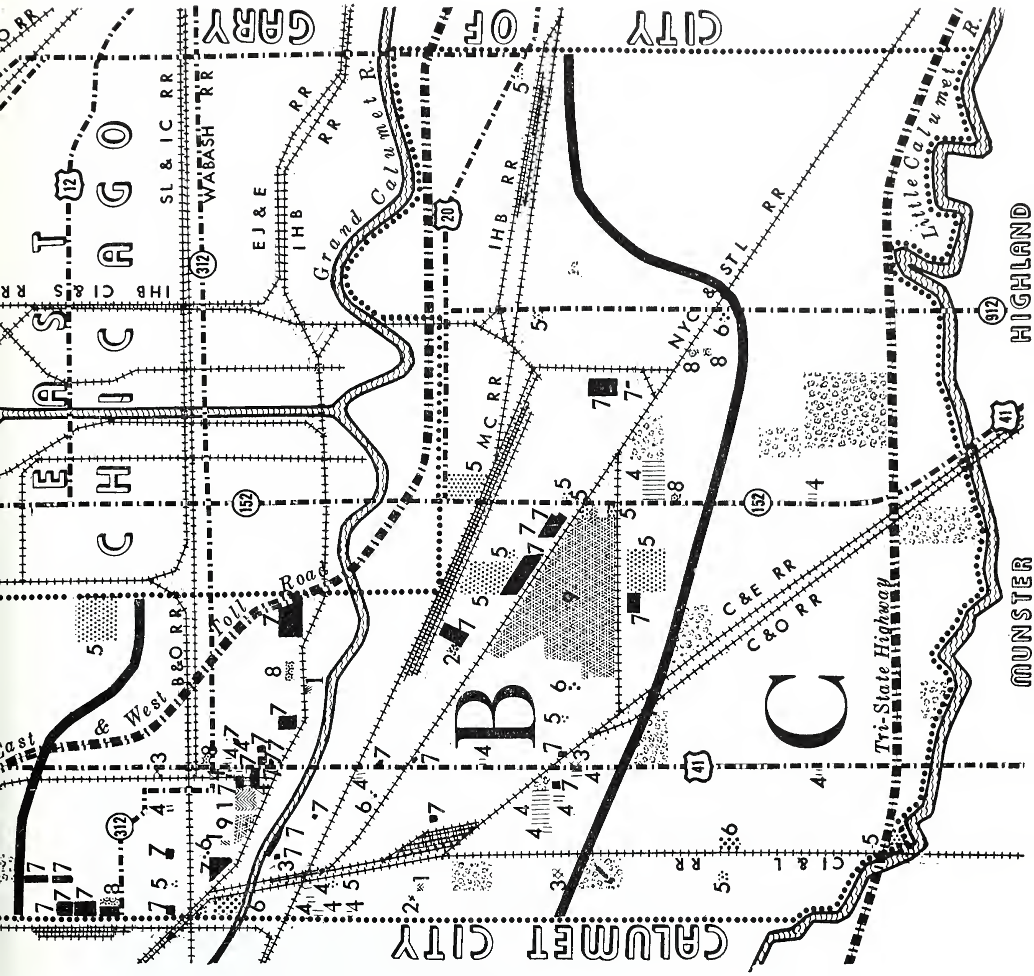

CITY OF GARY
EAST CHICAGO
CALUMET CITY
HIGHLAND
MUNSTER
Grand Calumet R.
Little Calumet R.
SL & IC RR
WABASH RR
EJ & E
IHB
IHB CI & S RR
RR
IHB RR
MC RR
NYC & ST L RR
C&E RR
C&O RR
B&O RR
CI & L RR
East & West Toll Road
Tri-State Highway
12
312
20
152
912
41
B
C

Figure 2

Manufactural Pattern

As the structure of industry can be traced to Hammond's past history, so also the present pattern of industry has its origin in the past. The Calumet area was used as a routeway before it became a settled area, and both the earliest Indian and American settlements were in advantageous positions along road and river confluence. Today also, Hammond's industrial pattern is related to transport facilities.

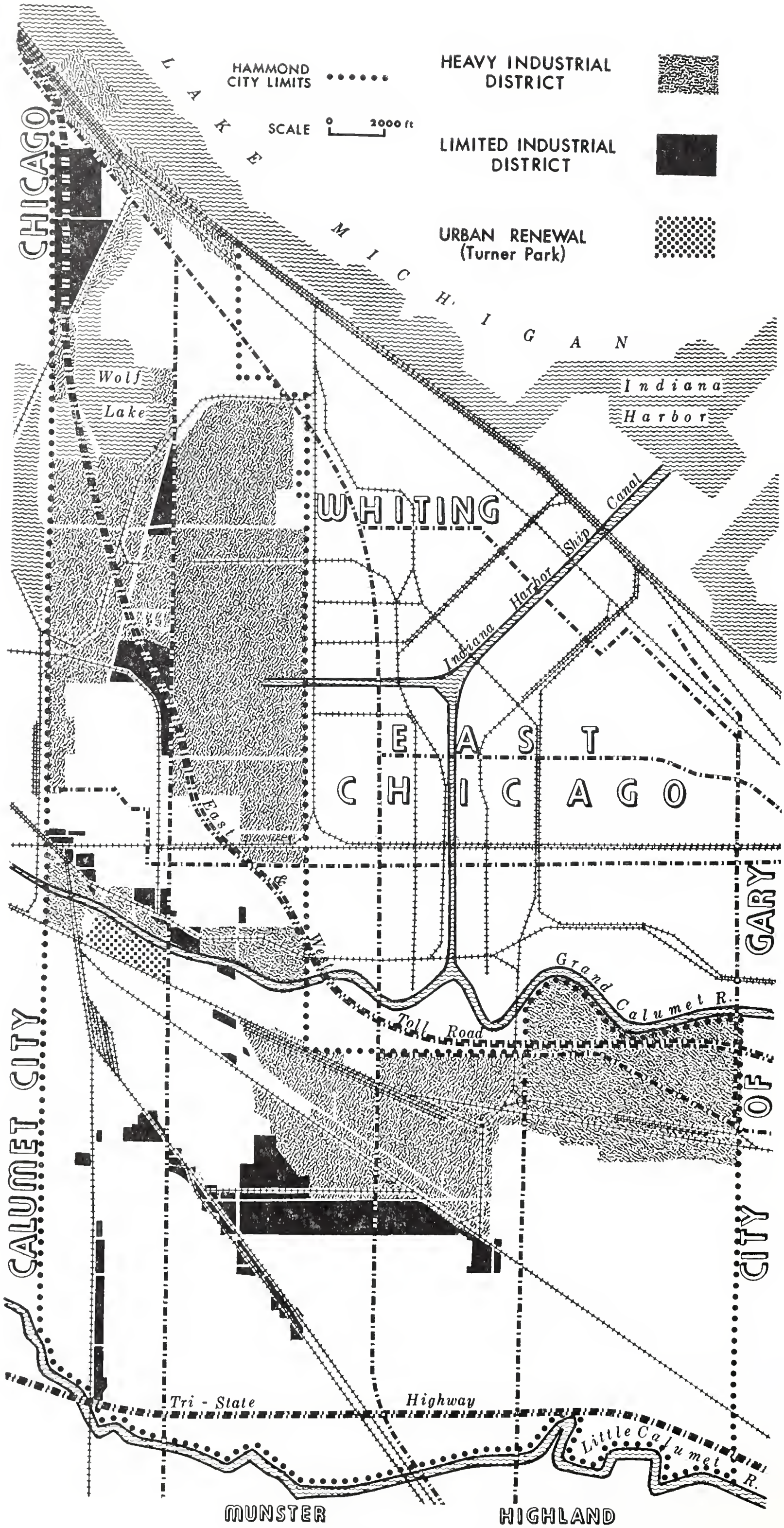

HAMMOND CITY LIMITS
SCALE 0 2000 ft
HEAVY INDUSTRIAL DISTRICT
LIMITED INDUSTRIAL DISTRICT
URBAN RENEWAL (Turner Park)
LAKE MICHIGAN
CHICAGO
Wolf Lake
Indiana Harbor
WHITING
Indiana Harbor Ship Canal
EAST CHICAGO
East & West Toll Road
Grand Calumet R.
GARY
CITY OF
CALUMET CITY
Tri - State Highway
Little Calumet R.
MUNSTER
HIGHLAND

Figure 4

Some sixteen main trunk and branch line railroads from Chicago to the east and south pass through Hammond (Figure 2).

The industrial pattern map shows that Hammond can be divided into three manufacturing regions. The central section "B," is the most densly industrialized, with industry patterned in proximity to the railroad lines. Fourteen railroads, as well as the Grand Calumet River, run through this central section of Hammond. All but 13 of the 97 industrial concerns, including all the Fabricated Metal Producers but one, lie within this area. "Good Transport" was one of the chief locative factors mentioned in the questionnaire by many of these firms. The firms are on the whole small in size. Two of the questionees from this area mention that it will be necessary to buy property elsewhere to deal with any future expansion of their works. Although the position of the railroads was a primary consideration in the location of these firms originally, many of them state that they are changing the emphasis of transportation from rail to truck. The Indiana East and West Toll Road, which runs through region "B," has been beneficial in speeding such deliveries, according to several correspondents. Three state highways, and U. S. 12, 20, and 41 traverse the region in N-S and E-W directions. As 32 of the fabricated metals producers are located in region "B," one can see the importance of rail and road connections from Central Hammond to other industrial areas of the Calumet.

In the northern part of Hammond, region "A," there are four railroad lines as well as lake and road transport. Here U. S. Highways 12, 20, and 41 now occupy a section of what used to be the old Indian Lake Shore Trail. There are fewer firms in this area, only eight altogether, but they include two of the largest ones. All of these firms except one occupy a larger amount of space than do the majority of industries in the more crowded central region. There still is much unoccupied land around Wolf Lake, some of which is being drained and filled and made usable. This land has become park territory and will not be used for industry. Several oil companies, though they do not refine petroleum, own a vast stretch of land in this region, and much petroleum is stored here. Some of the unused land has been sold by the larger companies to chemical concerns which use by-products from the petroleum refiners in Whiting as their raw materials for the production of chemical products.

Region "C," the southern section of Hammond, is served by four railroads, crossing through diagonally. The Tri-State Highway passes right through this section, and, according to the questionnaire respondents, trucking and parcel post are the more popular forms of transport for the fewer firms in this area. The five firms here manufacture drugs, cement blocks, and paper products, which do not necessarily require rail transport. The Little Calumet River, forming the southern boundary of Hammond, like the Grand Calumet, is not navigable. Along its banks are parks and a golf course. Thus, it has its importance in providing recreation for the industrial workers. It is also the main residential area of Hammond. It is interesting to note that the chief locative factor for one of the manufacturing concerns in region "C" was stated as: "pleasant country-like atmosphere."

Locative Factors

It has often been reported that business firms have little use for geography. This report, however, points to the conclusion that manufacturers are definitely conscious of the significance of the locative factor in the selection of industrial sites. Only five of the 58 firms which completed the questionnaire were unable to give any locational factor in the selection of their site. One of these mentioned that the original locative factors were not known at the present time owing to incomplete records. Many of the firms indicated two or three factors, and some as many as five or six. The following are the main locational factors reported in order of their frequency of mention:

1. Markets: Thirty-seven firms that is, 66 percent, stated that proximity to good markets was a major reason for the location of their plants. The markets were stated as being mainly in the densely populated Calumet area, Chicago, and the Midwest, and a few in Detroit and eastern cities.

2. Transport: As routes have always played an important part in the history of the Calumet, it is understandable that the second most important locative factor to be recognized by Hammond's manufactural establishments is good transport facilities. Eighteen firms (30 percent) evaluated this factor as a leading locative criterion, over half of them making specific mention of the railroads or highways. A few of the specific replies read: "regions where railroads concentrate"; "we had to be in the Chicago switching area"; "railroad gateway to west"; "railroad siding location"; "good road connection in every direction."

3. Land-Building Availability: Industry was started in Hammond by Hohman, Towle, Hammond and other real estate agents who were able to buy land at cheap prices. Fifteen questionnaire reports (25 percent) mentioned that cheap land and adequate building space were basic considerations in plant location today. Hammond borders greater Chicago and comes within the Chicago switching area, but land prices are cheaper than in Chicago. Several respondents mentioned these facts. One firm stated specifically that its move eastward from Chicago to Hammond where land was more easily available was part of the firm's expansion and decentralization program.

4. Steel Symbiosis: As previously mentioned, the largest group of industries in Hammond is connected with steel and metal products. The nearness to the Gary steel companies has been an important locational factor specifically mentioned by 11 firms. One branch firm moved to Hammond from San Francisco because it is a "steel pipe producing center."

5. Labor Availability: Eleven of the firms (18 percent) reported, "access to labor," "availability of skilled labor," "labor supply adequate," as being one of the important locational factors. Labor is predominantly male, especially in the heavy industries, where female labor is often restricted to office work. In a very few lighter industries, such as paint, drug, wall-paper, fiber, chemical, and

catering establishments, more women than men are employed. The greater number of employees are Hammond people who get to work by bus, car, or on foot. However, only 13 firms (21 percent) employ solely local labor. Some employees commute daily from Chicago and nearby sections of Illinois, and from places throughout the Calumet area. Trains and busses bring a few to work, but most employees drive in private cars.

6. Other Miscellaneous Factors: The above-mentioned factors were easily the most important. A few isolated factors were also mentioned by one individual firm or a small group of firms. Several gave an historical reason for the founding of the firm in Hammond, such as "The owner was born here," showing local initiative to make use of local industrial opportunities. A few mentioned proximity to raw materials as a chief locative factor. Two firms were food producers whose chief locative factor was proximity to raw materials, corn, and milk. Four firms state adequate water supply as a major factor. Waste disposal facilities, adequate power supplies, and favorable zoning laws were other individual responses.

Raw Materials

Of the firms responding to our questionnaire, 40 percent use raw materials originating within the Chicago-Calumet-Detroit region; 10 percent depend upon nation-wide or foreign sources, and 24 percent use both local and imported materials.

The importance of the first group shows the inter-relationships of industry within the Chicago-Calumet-Detroit areas. Twenty percent of the firms dependent on local materials alone use steel produced in the Calumet, pointing again to the importance of steel symbiosis. Nine firms use scrap metals obtained locally, and three use brass, aluminum, and other non-ferrous metals, or castings, obtained within the area. Some of the chemical industries use local materials entirely, and are dependent upon by-products from the refineries (e.g., hydrogen and solvents). Some of the smaller printers and wall-paper manufactures procure their paper and pulp from local wholesale dealers, and food companies use local or Midwest farm products.

Materials which are imported are again primarily related to the three major groups of industries: metals, petroleum, and printing. All the steel product companies are fabricative industries using semi-finished steel from local primary producers, especially those of Gary. None of the firms mentioned receives iron ore, either from other states or foreign sources. Copper, however, was reported by two firms as an import—from the Kenosha, Wisconsin and Great Lakes areas, and also some from Chile. Lead is imported from Mexico. Dolomite is imported from northwest Ohio and west central Nevada. Crushed limestone, sand, and slag are obtained from Thornton, Illinois. Various chemicals come from all parts of the United States: sulphur, chiefly from Texas; petroleum is pumped mainly from Kansas, Oklahoma, and Texas. A fertilizer company obtains some of its fish for fertilizer from the Great Lakes, but others from both east and west coasts, and the Gulf of

Mexico. The larger printing works own forest lands and lumber mills in northern Minnesota and Canada.

Not only has industry in Hammond remained diversified, but many firms also use both local and imported raw materials. Approximately half of the firms indicate alertness to alternative sources for their raw materials as safeguards for future security.

Increasing Dependence on Motor Transport

Questionnaire respondents show that the two predominant methods of transportation used by Hammond firms are trucking by road and freighting by rail, with increasing emphasis on the former. This applies not only to the import of raw materials, but equally to the export of finished products. Of the 58 firms which completed the questionnaire, 37 (62 percent) make use of both roads and railroads. Altogether, 48 firms employ trucking. Tri-State Highway passes through South Hammond, and the Indiana East and West Toll Road transects the city from the east to the northwest. U.S. 41 ties into Tri-State on the south, and U.S. 12, 20, and 41 are linked with the Toll Road on the north. Indiana 152 and 912 augment U.S. 41 for north-south transport, whereas Indiana 312 transects Hammond midway from east to west. Despite this seemingly adequate net of arterial highway service, serious traffic congestions occur, particularly those identified with the numerous rail crossings.

A student at Valparaiso University reports, for example, that his week-end trip to his home in southeast Hammond involves less auto travel time than that normally required in city driving from the railroad station in middle Hammond to his home. The long and frequent stops at railroad crossings, moreover, create a serious problem for the fire department. Because of this, extra stations have had to be established to provide proper fire protection in the segmented sections of the community. On the other hand, the multiple rail stops, in many instances guarded by gates, have their own way of arresting escaping burglars and other criminals intent on making a rapid get-away. This known fact is said to have actually operated as a significant deterrant to crime.

Forty-one firms reported use of railroads, five exclusively so, for transporting raw materials and manufactured products. As many as sixteen main trunk and branch lines serve the area. An outstanding rail facility, it is this very rail web reticulated with the city street and highway transportation pattern which creates the rail-road crossing problem mentioned above. Servicing the area are the Baltimore and Ohio; New York Central; Nickel Plate; South Burlington; Illinois Central; Soo Line; Chicago, South Shore and South Bend; Chicago and East Illinois; Pittsburgh, Fort Wayne and Chicago; Indiana Harbor Belt; Elgin, Joliet and Eastern; Chesapeake and Ohio; Michigan Central; Pennsylvania; Monon; and St. Louis, Wabash.

Six reporting firms use special tank cars on both road and rail systems. Four chemical and petroleum establishment have pipelines, and one firm receives raw materials by barge transport, though finished products are exported by tank cars.

Lack of Water Transport an Environmental Enigma

As is the case with its "inner elbow" neighbor to the east (East Chicago), Hammond has no navigable outlet on the Calumet, and, unlike East Chicago, does not have a lake harbor (4, p. 173). This fate for such a prominent industrial community, otherwise so strategically situated to navigation potentialities of the Great Lakes-St. Lawrence and Illinois River systems, is as much of a geographic anomaly as is the Calumet river system itself with its parallel east-west courses of both the "Grand" and the "Little." These streams, tortously feeling their way—the "Grand" between the original sand ridges deposited at the Tolleston stage of extinct glacial Lake Chicago, and the "Little" partly losing its identity in the Cady Marsh (Figure 1)—remind one of the "meandering" frustrations of the Hammond citizenry in their numerous attempts to get a navigable waterway outlet.

As early as the beginning of the twentieth century, the Hammond Chamber of Commerce "considered the straightening and dredging of the Grand Calumet River to be the most urgent community need." Congress looked with favor on such a project, and appropriated money for dredging, but U.S. district engineers refused to authorize an expenditure of money so long as the river through Hammond "remained winding and tortuous." In the early twenties, the Hammond Real Estate Board, recognizing that industrial competition was developing along the Drainage Canal to the west, initiated a movement for the establishment of a Joint River and Harbor Committee comprised of representatives of the Chamber of Commerce of Hammond, together with representatives from the Chambers of Commerce of Calumet City and of East Chicago, adjacent communities on the west and east, respectively. This combined chamber group felt that with the procurement of deeds of dedication for the straightening and widening of the river through the three contiguous cities, the U.S. government would not only make the river navigable but also improve the Indiana Harbor Canal, thus opening up a commercial outlet to the Illinois River via the Cal-Sag while at the same time providing an internal route from the Indiana Harbor to the Calumet Harbor on Lake Michigan (Figure 3). The Real Estate Board felt convinced that the project properly completed "would do more to stimulate the industrial development of the region than anything else that could be undertaken." A brochure was issued (5) with engineer maps illustrating section by section relevant data for the development of the Calumet River project. Reportedly in 1930, a special trainload of people from the districts concerned, a total of 67 people including several mayors, went to interview President Hoover in Washington, but were told that the money was not forthcoming. Later, in the Roosevelt era, permission was granted, but then the war interrupted the project (6).

Sound geographic goals such as this cannot forever lie dormant. In fact, the development of a navigable Grand Calumet is now on the drawing board, not only to serve Hammond but also the East Chicago community. As was earlier reported in our East Chicago-Whiting study (4), the Calumet-Sag Navigation Project, authorized by Congress with the approval of the Rivers and Harbors Act of 1946, provides, among other things, for the deepening of the Grand Calumet from its present four feet to nine feet, and from its present width of approximately 100 feet to 225 feet from the junction of the Grand Calumet with the Little Calumet. But such construction does involve extensive relocation or reconstruction of numerous bridges—both highway and railway—now without adequate vertical clearances. While the federal government is prepared to move ahead on the project, local interests must also provide the necessary rights of way, areas for soil disposal, and relocation or alteration of utilities affected by the channel improvement project. Reference to the engineers' map (4, p. 173), reveals the numerous rail and road bridges which are involved in the project.

Tri-City Harbor and Port Proposal

Just as the navigation potentials of the Indiana section of the Grand Calumet are linked Illinoisward to the Calumet Harbor on Lake Michigan and the Cal-Sag outlet to the Illinois-Mississippi rivers to the west, so the commercial potentials are politically centered on the tri-cities of Hammond, Whiting, and East Chicago of Lake County, Indiana. Indiana, like all other states on the Great Lakes, has, ever since it was founded, agitated for lake harbor-port developments. It is understandable that the most intensely industrially developed area in Indiana, with the greatest concentration of rail and highway traffic, and occupying the most strategic geographic position in its metropolitan relationships to Chicago and the head of Lake Michigan navigation, should have manifested long-time interests in securing a public deep-water harbor on its shores. Accordingly, the Chambers of Commerce of the three communities have acted in concert to petition the federal government for the development of such a harbor. Several proposals have been suggested and reported upon by engineers. One of the projects envisions "connecting the existing South Chicago Harbor and Indiana Harbor with a breakwater," and creating new land for port and industries. Another purposes the establishment of a Tri-City Port by connecting the present breakwater of the State Line Generating Company on the west with those of the Inland Steel Company on the east. Another geographic version proposes to connect 2½ miles of existing breakwaters at Indiana Harbor and at the state line with four miles of newly constructed breakwater. The opinion has been expressed that the Tri-City harbor would provide a deep-water port with sufficient dock facilities from made land, which results from port construction. This port would be available for barge traffic from the Calumet Sag Canal and Illinois River, without requiring barge traffic to go "outside" into "open water" (7). Properly integrated geographic planning establishing adequate channels from the proposed harbor site along the Indiana Harbor Ship Canal and the Grand Calumet River is a major objective, then, in which the three communities share joint responsibilities. Properly developed navigation waterways might well help to bolster the area's declining manufactural employment, said to have been reduced by 20 percent within the last five years in Hammond alone. The significance of the port itself to the entire Midwest lies in its unique terminal facility for both the St. Lawrence Seaway and Mississippi-Gulf traffic systems.

Why has not the Tri-City harbor-port materialized to date, technically supported as it has been by engineer and geographer alike. The answer seems as complex as is the geographic matrix of the Calumet region itself. Geographic change has a way of focusing today on one site, tomorrow on another—not always the result of expert evaluations of comparative sites alone but at times resulting from a combination of technical surveys and political factors which of themselves are not readily resolvable. In any event, the opinion has been expressed that proposal of the Tri-City project has been "sidetracked because of the efforts being made on behalf of the Burns Ditch area." In contrast with the Tri-City industrial-commercial complex, the Burns Ditch area in Porter County, some 18 miles to the east, is a "pristine" dunal lake land.

Industrial Zoning

Figure 4 was composed from 10 sheets of the Hammond Master Plan brochure (8) to present a unified view of the city areas zoned for limited industries (including light industries) and heavy industries.

As defined by the brochure: A Light Industrial Use is one which ordimarily uses only light machinery; is conducted entirely within closed, substantially constructed buildings; does not use the open area around such buildings for storage of raw materials or manufactured goods, or for any industrial purpose, other than loading and unloading operations in the rear; and which is not noxious or offensive, by reason of emission of smoke, dust, gas, fumes, odors, noise, or vibrations, beyond the confines of such buildings.

A Limited Industrial Use is one which requires both buildings and open areas for manufacturing, fabricating processes, heavy repairing, dismantling, storage or disposal of raw materials, manufactured products, or wastes; which is not injurious to vegetation; and which is not noxious or offensive, by reason of the emission of smoke, dust, gas, fumes, odors, or vibrations beyond the limits of the premises upon which such industry is conducted.

A Heavy Industrial Use is one which requires buildings and open areas for manufacturing, fabricating, processing, heavy repair, dismantling, storage, or disposal of raw materials, manfactured products or wastes; which is not injurious to health or safety of humans or animals, or injurious to vegetation; and which has not been declared a nuisance in any court of record.

These classifications are further differentiated by such criteria as pertain to dimensions of buildings, parking, loading, and yard space.

A number of changes in industrial rezoning have been made since 1951, the date of the planning brochure. One areal change occurs in each of the following types: "General Commercial" to "Limited Industrial"; "Heavy Industrial" to "Class C Residential"; "Limited Industrial" to "Class C Residential"; "Limited Industrial" to "Local Business"; "Heavy Industrial" to "Class D Residential"; and "Class A Residential" to "Limited Industrial." Considering the heavily industrialized character of the community, the areal tracts affected are relatively limited, and indicate a comparative industrial zoning stability. Our investigation was partly concerned with the climate of local appraisal as to the adequacy of industrially zoned land for the present and foreseeable future. Industries generally were found to be quite satisfied with the industrial zoning pattern. At least one heavy industry specifically cited good zoning laws as the areal factor for locating in Hammond. The Chairman of the Chamber of Commerce Industrial Committee feels "There is presently adequate land available for industrial use, and in addition, there are lands and plants which have been abandoned by former industries which could readily be converted. The near lands available are located generally in the area between Columbia Avenue and Indianapolis Boulevard north of 167 Street [center of "B" section, Figure 2] and south of Michigan Avenue on the southeast side of the city [northeast part of "C" section], and the lands bordering on Sheffield and Calumet Avenues in the northwest portion of the city [south-central "A" section]" (7).

On the other hand, it has also been pointed out by the President of the City Plan Commission (6) that certain limitations for industrial expansion do exist for particular site quality. For example, the eastern part of section "C" was originally bought by the Nickel Plate railroad for transport. But this area (some 150 acres), considered good for industry, has been classified as residential, and 40 acres of it purchased by the School System. In the northwest, reclaimable land around Wolf Lake is allocated to park use, and thus not available to industry. By resale, some industrially zoned land, sited in "B," is restricted to research laboratory rather than manufacturing.

Urban Renewal

Urban renewal is significantly related to the zoning and planning programs of complex urban communities, especially those heavily industrialized as are Hammond, Gary, and East Chicago, each of which has a government subsidized urban renewal program.

Urban renewal may be instituted with or without the aid of federal and state funds. Federal subsidization is provided for in Section 2 of Public Law 171, known as the "Housing Act of 1949." It is designed to assist in the "elimination of substandard and other inadequate housing through clearance of slums and blighted areas, and the realization as soon as feasible of the goal of a decent home and a suitable living environment for every American Family." Recognizing that all community interests—residential, commercial, and industrial—have a vital stake in rehabilitation of "blighted" areas and in safeguarding other areas against community decay, a Redevelopment Commission was formed in Hammond. This Commission came to the conclusion that there was a need for community improvement: better city codes and planning to promote present and future welfare, increased opportunities for private enterprise, and rebuilding older sections of the city to provide better homes and neighborhoods. The Commission pointed out that although Indiana legislature had adopted the "Redevelopment of Cities and Towns Act" in 1953, and were thus eligible for a grant of two-thirds the total cost for slum redevelopment from the federal government, Hammond had not yet taken any action by 1960. The Commission had an Urban Renewal Survey taken and reported that more than 1,800 residences are dilapidated, another 700 require major repairs, four schools need replacement, some 5,000 downtown parking spaces, 25 acres for parks and playground, and 400,000 square feet of office space are immediately required, and the railroad barriers now dividing the downtown business section should be eliminated (9). These recommendations pertain to Hammond's industry in an indirect, but vital, way. Here, as elsewhere, worker contentment promotes labor competence.

Since 1960, the Urban Renewal Commission has established a program which will redevelop a large area of downtown Hammond between Hohman and Calumet Avenues, east to west, and between the Grand Calumet River and the Michigan Central Railroad, north to south. The projected site is known as the Turner Park Area (see Figure 4). By 1963, plans for its redevelopment should be completed and the committee is confident that permission will be granted for the plans to be executed. Though urban renewal projects may provide sites for industrial use (e.g., in Gary, Evansville, and South Bend, Indiana), the Turner Park Area is restricted solely to residential development. As noted in Figure 2, only four small industries are involved here.

Hammond's Future Industrial Potential

Summary analysis of Hammond's geo-historical profile reflects a disparate emphasis on the engineering and political aspects of industrial development as compared with scientific environmental appraisal by the professional geographer. The political geography of this northwest corner of the state of Indiana—the highly artificial division into three corporate communities—bears little concordant relationship to the physical, economic, and commercial geography inherent in the region. Had more attention, for example, been given in the past to the total environmental pattern, a unified geographic entity might well have led to a deep-water harbor on Lake Michigan a long time ago. And if the geography of the yesterdays called for a harbor-port at the Hammond-Whiting-East Chicago-Gary site, then the geography of today does even more demand such consideration. It is, therefore, not surprising that as of the time of this writing an appropriation by Congress of $50,000 is being used to re-examine the port-expansion feasibility at Indiana Harbor.

A second summary observation points to the need of well-integrated efforts on the part of Hammond's civic and political agencies, especially the Chamber of Commerce, the City Plan Commission, and the City Council. It is the expressed opinion by the Chairman of the Industrial Committee, M. Elliot Belshaw, that "There is less than a maximum effort being made to attract new industry or convert present industrial facilities to a more timely use," and "That Hammond is badly in need of small industry which can be located in areas sometimes described as Industrial Parks. Heavy industry is becoming far to cyclical and employment opportunities within the city are declining at a rather serious rate."

Thirdly, aside from sound internal planning of the city itself for optimal geographic space relationships of its several urban functions, more and more recognition must be given by Hammond planners to the planning programs of its neighbors—both on the Indiana and Illinois sides. This is an added problem that inheres in a "wedged in" community like Hammond. Not only that, increasing economic interdependence and intercommunication among communities on an ever-expanding regional scale call for active participation in any newly proposed planning legislation such as is now contemplated for the five counties of northwest Indiana—Lake and Porter (within the "Metropolitan Complex of Greater Chicago"), and LaPorte, St. Joseph, and Elkhart. Indiana Community Resources Association has formed a legislative committee to study the problems of regional planning for this area—"problems involving transportation, recreation, water, land use, drainage, utilities, and schools." As reported by Arthur Tuesburg, Executive Director of the Porter County Plan Commission, "This legislation will be introduced in the 1963 General Assembly and represents a significant step in an effort to provide a Regional Plan Commission for Northwestern Indiana."

Finally, still another planning problem presents itself for Hammond. Politically separate, but geographically contiguous with the industrial communities on the Illinois side, Hammond will have to co-ordinate its own planning with that of northeast Illinois as well. Truly interstate geographic planning here is needed to avoid provincial thinking on geographic resources along purely political lines.

Acknowledgments

The authors are grateful for the co-operation of all Hammond industrialists who have supplied questionnaire information, and for the information received otherwise from local officers and literature sources herein specifically acknowledged.

As part of a continuing series of industrial surveys by Valparaiso University's seminar in "Geographic Problems," we have had the field assistance of Professor Elmer Hess' class in "Urban Field Survey." Gary Engerer and Carol Gerlitz did initial inventory and other work on the project; and Benton Lair assisted in map work. All such services are deeply appreciated and recognized as mutually helpful as staff and student try together to develop local regional awareness of some of the major industrial problems of our times.

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Distribution of the Inglefield and Dicksburg Hills Sandstone Members in Posey and Vanderburgh Counties, Indiana[1]

CHARLES E. WIER and W. A. GIRDLEY, Indiana Geological Survey

This study of the Inglefield and Dicksburg Hills Sandstone Members of the Patoka Formation (8) was initiated after the senior author had experienced great difficulty in tracing across Gibson and Vanderburgh Counties the upper Pennsylvanian coals and limestones that occur above the West Franklin Limestone Member. Nearly all data for this report came from interpretation of electric logs of oil and gas test wells. Four wells per section (one well per quadrant) were used where possible, but some sections contained either no drill holes or only a few. Some of those sections with only a few drill holes did not have any usable records. Approximately 900 records were used. In areas adjacent to the outcrop of these sandstones electric logs were not always reliable, and the sandstone units were not recorded. In this area the upper 100 feet of the hole either is not logged or cannot be interpreted because the effect of fresh surface water distorts the reading. Few outcrop data are included in the present interpretation, but even much additional fieldwork along the outcrop area would not improve the data substantially because each outcrop exposes only a small part of the total thickness.

The Inglefield Sandstone Member was named and accorded formational status by Fuller and Ashley in 1902 (3). Originally the name was applied to 80 to 100 feet of sandstone above the Ditney Coal (fig. 1) in the vicinity of Inglefield, a small village 9 miles north of Evansville in Vanderburgh County. Later Fuller and Clapp (4) stated that the Inglefield Sandstone unconformably overlies the Ditney Coal and adjacent shale, underlies the Parker Coal, and is 100 to 150 feet thick. The sandstone at the type locality and most of the sandstone that they mapped as Inglefield occur in the lower half of the interval between the Ditney and the Parker Coals.

The Dicksburg Hills Sandstone Member was named as a formation by Malott in 1939 (5) for a 50-foot exposure of massive sandstone in the Dicksburg Hills in southern Knox County. As defined by Malott, this sandstone is equivalent to the upper part of the Inglefield of Fuller and Clapp. Malott felt that it was necessary to name the Dicksburg Hills Sandstone as a separate unit because he was able to map a 20-foot shale unit that contained three thin coal beds and two thin limestone beds in a position halfway between the Ditney and the Parker Coals. He named this unit the Hazelton Bridge Formation for outcrops west of Hazelton in Gibson County (5). Thus he redefined the Inglefield as the sandstone occurring in the lower half of the Inglefield of Fuller and Clapp, that is, above the Ditney Coal and below the Hazelton Bridge Formation of Malott. The Dicksburg Hills Sandstone member is

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[1] Published with permission of State Geologist, Indiana Department of Conservation, Geological Survey.

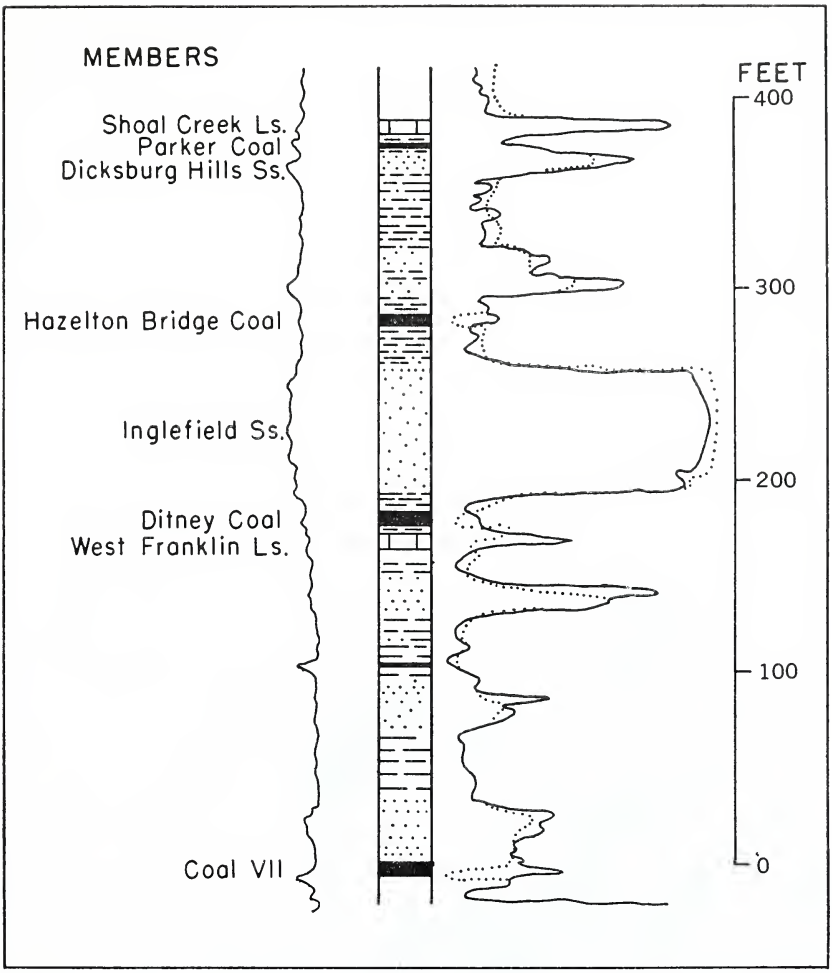

MEMBERS
Shoal Creek Ls.
Parker Coal
Dicksburg Hills Ss.
Hazelton Bridge Coal
Inglefield Ss.
Ditney Coal
West Franklin Ls.
Coal VII
FEET
400
300
200
100
0

Figure 1. Representative electric log illustrating the stratigraphic position of the Inglefield and Dicksburg Hills Sandstone Members. Nomenclature from Wier (8).

a sandstone that lies in the upper part of the Inglefield of Fuller and Clapp and is above the Hazelton Bridge Formation of Malott and below the Parker Coal. The thickest and most widespread coal in Malott's Hazelton Bridge Formation is now called the Hazelton Bridge Coal (8). Some confusion still exists as to the correlation of the Inglefield Sandstone with other named sandstones. Earlier workers incorrectly called the Inglefield Sandstone the Merom Sandstone, because outcrops of the Inglefield look like those of the Merom that are 75 miles to the north at Merom, Sullivan County (7). Malott (6) continued to mistake the Inglefield for the Merom Sandstone in the southwestern part of the State, and later workers followed his example (2). The Merom Sandstone, however,

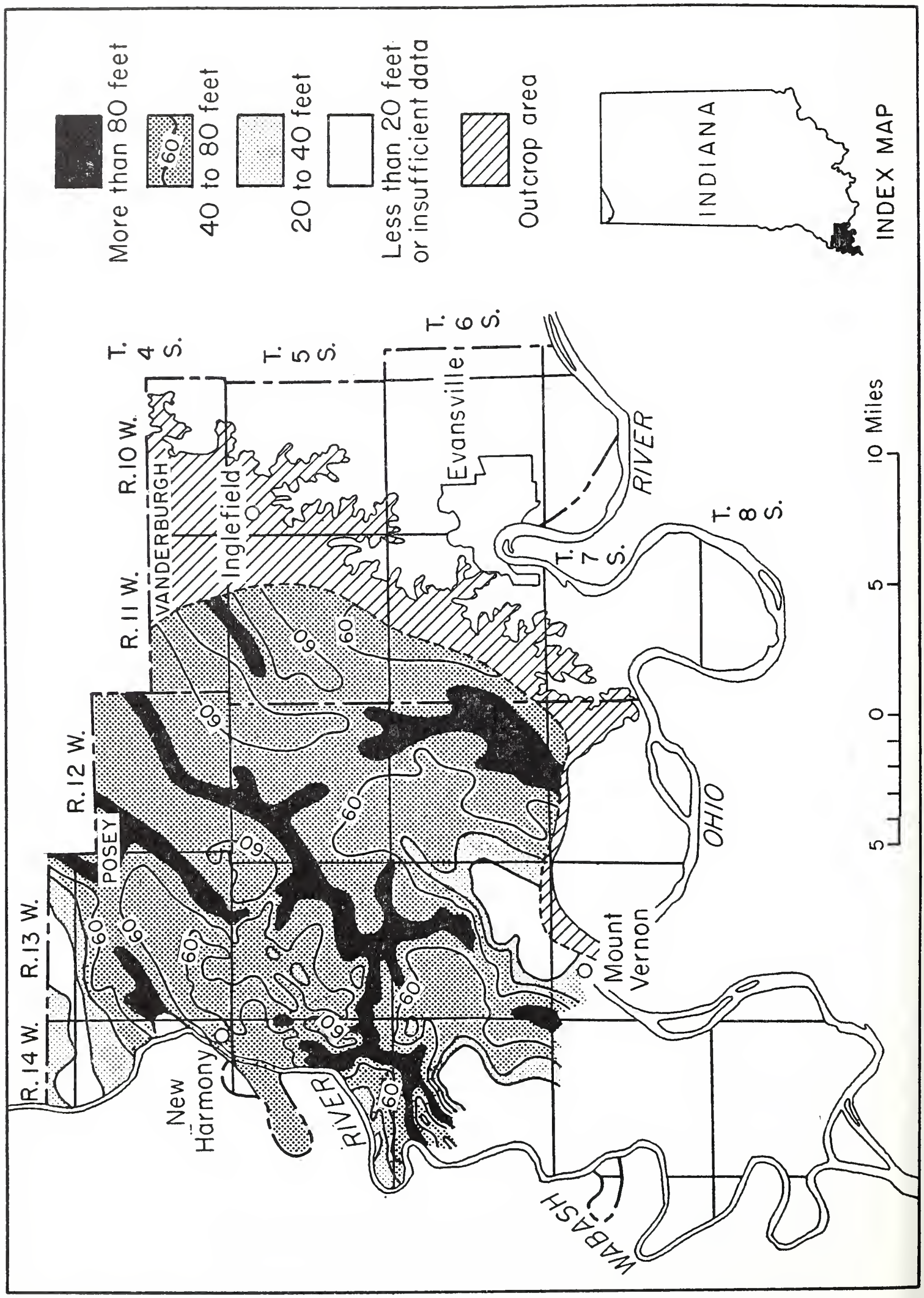

More than 80 feet
40 to 80 feet
60
20 to 40 feet
Less than 20 feet or insufficient data
Outcrop area
INDIANA
INDEX MAP
R.14 W.
R.13 W.
R.12 W.
R.11 W.
R.10 W.
T. 4 S.
T. 5 S.
T. 6 S.
T. 7 S.
T. 8 S.
POSEY
VANDERBURGH
Inglefield
Evansville
New Harmony
Mount Vernon
WABASH
RIVER
OHIO
RIVER
60
5
0
5
10 Miles

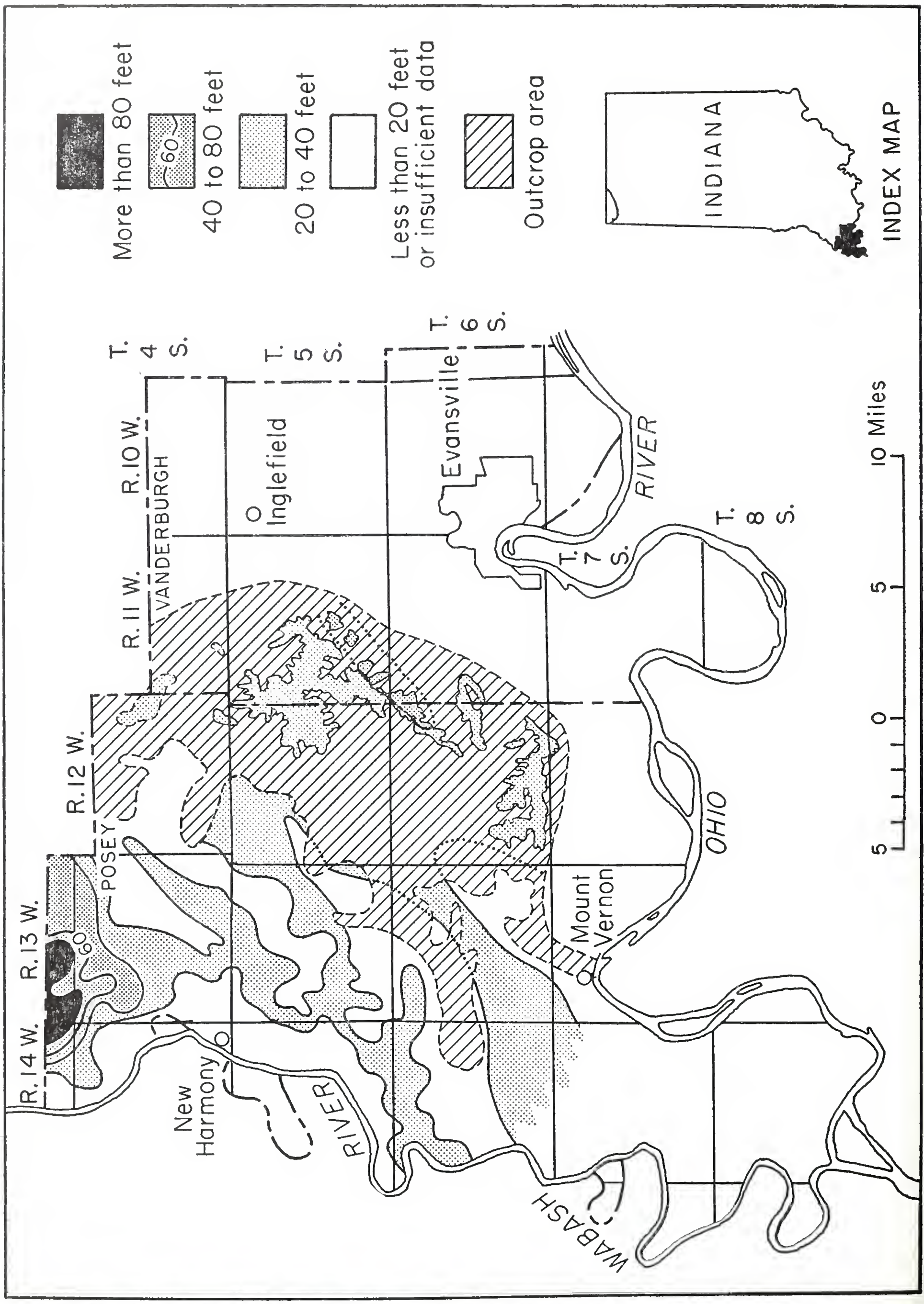
Figure 2. Map of Posey and Vanderburgh Counties showing thickness of the Inglefield Sandstone Member.

is now known to be approximately 200 feet higher stratigraphically than the Inglefield.

Both the Inglefield and the Dicksburg Hills Sandstone Members have sharp variations in thickness and irregular areal distribution in much the same manner as other Pennsylvanian sandstones. The interval between the Ditney and the Parker Coals may contain sandstones that are tens of feet thick and that weather out as impressive massive vertical bluffs; it may consist of bands of sandstone and shale, or it may be entirely a shale that is not exposed or is poorly exposed at the surface. Because the most obvious and thicker outcrops of the stratigraphic interval between coals were sandstones, some earlier workers believed that the entire interval was filled with sandstone.

The Inglefield Sandstone crops out in a diagonal line from northeast to southwest across Vanderburgh County (fig. 2). In northern Vanderburgh County outcrops of this massive sandstone are common. West of the outcrop the Inglefield Sandstone is well developed and is more than 125 feet thick in some localities. The sandstone is more than 20 feet thick over almost the entire area of Vanderburgh and Posey Counties where data are available. The thick areas of sandstone are irregular lenses extending in a northeast-southwest direction (fig. 2). These are interpreted as channel-fill sandstones and are continuously more than 80 feet thick. Some sandstone that is nearly 80 feet thick in the adjacent area may be part of the channel fill, but essentially all sandstone that is less than 60 feet thick surely represents the sheet phase of deposition. However, Posey County may have been the site of a delta at the time that the Inglefield Sandstone was deposited. The pattern of thickness in Tps. 5 and 6 S., Rs. 13 and 14 W., seem to show a distributary pattern. Sandstone deposited in the sheet phase is, in most places. less than 20 feet thick. Only in two small areas where data were available was the Inglefield Sandstone less than 20 feet thick: in a nearly east-westward-trending area in northwestern Posey County and in a northeast-southwestward-trending area in southern Posey County just north of Mt. Vernon. The Ditney Coal is missing in some records in an area where the sandstone is more than 80 feet thick and the sandstone rests directly on the West Franklin Limestone. In T. 5 S., R. 13 W., the entire West Franklin is missing in a few records, and the interval occupied in other places by the West Franklin is filled with sandstone. A sandstone in this position below the Inglefield Sandstone and immediately below the Ditney Coal was mapped in southern Illinois by Andresen (1) as the Trivoli Sandstone. Perhaps the lower part of the sandstone here mapped as Inglefield is actually the Trivoli, but the present authors could not separate this lower part and thus concluded that this sandstone represented a channel that had been cut into the Ditney Coal and West Franklin Limestone and filled with Inglefield Sandstone.

The Dicksburg Hills Sandstone crops out farther west in an area along each side of the Vanderburgh-Posey county line (fig. 3). Much of the west side of the area indicated on the isopach map as outcrop area is really covered with thick unconsolidated materials, and there the


More than 80 feet
60
40 to 80 feet
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INDIANA
INDEX MAP
T. 4 S.
T. 5 S.
T. 6 S.
T. 7 S.
T. 8 S.
R. 10 W.
R. 11 W.
R. 12 W.
R. 13 W.
R. 14 W.
VANDERBURGH
POSEY
Inglefield
Evansville
Mount Vernon
New Harmony
60
WABASH
RIVER
OHIO
RIVER
5
0
5
10 Miles

Figure 3. Map of Posey and Vanderburgh Counties showing thickness of the Dicksburg Hills Sandstone Member.

sandstone is not exposed. The Dicksburg Hills Sandstone is much thinner in Posey and Vanderburgh Counties than the Inglefield. It is not more than 40 feet thick over most of the two counties and is either less than 20 feet thick or absent in nearly half of Posey County. Only in the extreme northwestern part of Posey County is it more than 80 feet thick. Like the Inglefield Sandstone, it shows channel-fill sandstone areas trending northeast-southwestward. These channels, however, contain only 20 to 40 feet of sandstone.

On most electric logs the Dicksburg Hills Sandstone is easily separated from the Inglefield. In a few records it was difficult to separate the two because the entire interval was filled with alternating beds of sandstone and shale, and neither the Hazelton Bridge Coal nor its superjacent limestone could be identified with certainty. Nowhere in Vanderburgh and Posey Counties was the entire interval between the Ditney and Parker Coals filled completely with sandstone.

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Our Recreational Needs and Long-Ranged Potential Plans for Public Outdoor Recreation in Indiana

THOMAS FRANK BARTON, Indiana University

It is becoming increasingly obvious to more and more people that Indiana today does not have sufficient public outdoor recreational facilities for its own citizens. What there is available cannot accommodate the expanding tourist industry. Present facilities are overused and deteriorating. If the present outdoor recreational accommodations now open to the public are not expanded, then the use of those now available will need to be restricted in order to save them from complete deterioration.

In spite of present limitations, Indiana does have many first-class potential recreational areas that remain neglected and undeveloped. Southern Indiana's Recreational Triangle contains assets which, if developed, would make this region not only the leading recreational area of the state but one of the chief ones in the entire Ohio River watershed (1).

Today, Indiana balances precariously on the horns of an unfortunate dilemma. While it needs additional public outdoor recreational facilities for its own citizens and for an expanding tourist industry, its recreational potentials remain primarily undeveloped.

Needs

Some of the primary reasons why demands for public outdoor recreation accommodations have skyrocketed far above the state's limited facilities are: (1) rapid increase in population, (2) urbanization and industrialization of a former agricultural state, (3) a boom in camping, (4) failure of Indiana's General Assemblies to provide adequate funds for (a) the development of accommodations on State-owned land or (b) for the purchase of desperately needed additional acreage and (5) the emphasis placed by both major parties' leaders on the need to promote a tourist industry.

Increase in population. In long-range planning, forecasting future population growth is hazardous, but failure to do so can be disastrous. Between 1950-1960, Indiana's population increased at the rate of 18.5 per cent. If this growth continues at the same rate for the next four decades, the state will have a population of 6.5 million by 1980, and over 9 million by 2000. To some forecasters, these statistics seem too conservative and they feel that the planners should estimate from 7 to 8 million people in Indiana by 1980 and over 10 million by the year 2000 (2). But to return to the more conservative estimate, if the population should double in the next four decades, then twice the amount of acreage and facilities that are now available would be needed by 2000. That is providing there were adequate acreage and facilities today. But since this is not true and since the population increase may be greater in the decades to come than it has been during 1950-1960, and especially since the state policy is to develop a thriving tourist industry, shouldn't plans be made now to triple the public outdoor recreational accommodations and acreage between 1960-2000?

Urbanization. Perhaps the second most important factor to consider when making these long-range plans is the degree of urbanization. In 1960, over three-fifth's of Indiana's citizens lived within the political boundaries of cities, and many more occupied the unincorporated subdivisions and suburbs clustering around the major urban centers. Moreover, the industrial potential of the state may influence future population growth to exceed the present and national 18.5 per cent increase occurring between 1950-1960. Each new decade will find a higher and higher percentage of Indiana people living in the cities. And, it will be these people who will crowd the country-side in search of relaxation in state parks, forests, monuments, lakes and rivers and other recreational areas.

Boom in camping. During the past decade the growth of camping has far exceeded that of campsite accommodations in both Indiana's parks and forests. Between June 30, 1955 and June 30, 1961, the number of campsites in Indiana State Parks increased by 256 per cent (3).

> ". . . This rapid increase of campground use is 26 times greater than the rate of increase in the number of people who entered the Indiana State Parks for the same period of time." (4).

With the construction of 253 campsites between 1959-1961, the Division of Parks by August 1961, was managing 920 sites while the Division of Forestry was managing 500. Yet during the summer months of 1961 all of these 1,420 campsites could not adequately accommodate the flood of campers who were crowding into these areas.

This congestion cannot be remedied by suggesting that campers take a room in the lodge or inn. Reservations here, especially in the months from May through September, must be made months in advance. Most of these lodges and inns constructed before the Second World War were large enough to serve the public at that time. But today even if the number of rooms available were doubled, it would still be necessary for one to make reservations in advance. What accommodations the state does have at present a tourist will find quite adequate since Indiana's system of park lodges and inns ranks among the best in the United States. There just aren't enough rooms at present for now or future needs.

Inadequate funds. The men responsible for providing adequate recreational opportunties have been painfully aware of the avalanching demands. The Division of Parks in its 1961-1963 budget included a request for $296,000 for campground expansion but the amount allocated by the 1961 Legislature fell far short of the proposed budget (5). Yet, every year the number of campers increases about 40 per cent, more than the state's water and sanitation facilities can handle (6). Health dangers and human frustrations multiply on weekends when often as many as three times the number of people occupy campsites intended for a much smaller number—this fact endangers health and ruffles tempers —doing the opposite of what the word recreation implies.

Just at a time when Indiana wants to expand its tourist industry, its state parks and forests personnel may be compelled to turn away many who seek rest and recreation.

Administrators in Indiana's Department of Conservation have tried to avoid the dilemma of having public officials promote a tourist industry while public outdoor accommodations are still totally inadequate. To improve these conditions, Indiana's Division of State Parks prepared and submitted, under the efficient management of Director Kenneth R. Cougill, a modest request of $2.5 million for the 1961-1963 biennium (7). The 1961 General Assembly chopped $2.1 million from this request (leaving only $400,000) and added a special $200,000 grant for buying land at the new Chain O'Lakes Park near Ft. Wayne. Granted that land should be bought for the Chain O'Lakes Park, yet to appropriate only $400,000 for 21 parks is not realistic nor is it in keeping with good park management. This fact could be a major roadblock to the development of a tourist industry in Indiana. In contrast with the action taken in Indiana, Kentucky through a bond issue made ten million dollars available in 1961 for park development.

Administrators interested in recreational expansion in the state forests received the same discouraging treatment from the 1961 General Assembly as had the Division of Parks. In Bedford, on December 17, 1960, at a joint meeting of (1) representatives of Southern Indiana Incorporated and (2) a committee devoted to the improvement of recreational facilities in Indiana State forests, it was estimated that:

> ". . . needed public improvements in Indiana state forests during the biennium of July 1, 1961-June 30, 1963 would cost $860,500" (8).

Despite the fact that this group had cut this request of what the Division of Forestry actually needed in half, the 1961 session of the Indiana General Assembly appropriated only $400,000 of new money for all expenditures in the Division of Forestry (9). What part of this amount will be spent for recreational facilities during the biennium is not known.

A few months after the legislature adjourned, Director Foltz estimated that:

> ". . . The state Division of Forestry, which administers state forests, needs to double its present 500 campsites merely to meet current demand.
>
> "Development of a campsite includes laying roads, running water and sewage facilities to the site and, often, installation of an electrical system. All this may cost from $50 to $500, depending on how close the campsite is to existing facilities.
>
> "The average cost is about $300 . . ." (10).

Consequently $180,000 will be needed if the 500 additional campsites in state forests and the 100 other state parks are constructed and put to use in 1962.

In September, 1961, Mr. Wilcox reported that about 10,000 of the 118,000 acres in state forests were used primarily for recreation (exclusive of hunting) (11). Looking into the future he estimated that by 1975 Indiana will need to utilize 25,000 acres in state forests chiefly for recreational purposes. And that by 2000 he feels 50,000 acres of Indiana's state forests will be turned into recreational areas and used for picnicking, bathing, boating, etc., exclusive of hunting, on almost every acre (12).

But can administrators justify the using of approximately half of the land in state forests for recreation? Hasn't the state maintained an adequate parkland acquisition program on its anticipated increase in population?

Lag in land purchase. In their recent sessions the Indiana General Assemblies have not only failed to provide adequate funds for the development of facilities in state parks and forests, but they have also failed to maintain an adequate land purchase program (Refer to Table 1).

Table 1. Acquisition of Land in Indiana State Parks and Indiana State Memorials (13).

Decade	*Acres*
1911-1920	3,414
1921-1930	21,238
1931-1940	1,576
Decade	*Acres*
1941-1950	14,497
1951-1960	9,803
	50,528

During the thirty-year period 1930-1960, the state acquired 25,876 acres for parks, an average of only 863 acres a year. About the same amount of land was acquired for state parks and memorials during the fifteen-year period of 1916 to 1930 as was acquired between 1930-1960 (14).

Moreover, the General Assemblies cannot say that they have neglected to acquire land for state parks because they were accelerating land purchases for state forests. In the five-year period preceding July 1, 1960, the Division of Forestry had increased the acreage in the state forests by only 4,751 or an average annual purchase of only 950 acres (15). This rate is lower than that which existed before the Second World War.

The purchase of land by the state for recreational and forest utilization need not take good farmland out of cultivation or off the tax rolls. Forest surveys show that four million acres in Indiana are best suited for growing trees and for recreation facilities and not fit for crop production. In spite of these studies, the state has failed to expand and and develop adequately public-owned land for such purposes (16).

Tourism. In spite of the fact that Indiana's outdoor recreational accommodations had been woefully inadequate, in 1961 the political leaders in both Democratic and Republican parties announced that the tourist industry in the state had been neglected. In July, 1961, Lieutenant-Governor Richard O. Ristine (17), after returning to Indianapolis from attending a 12-state Midwestern Regional Council of State Government at Rapid City, South Dakota, announced that:

> "Competition for the tourist dollar is getting stiffer all the time. Every state but Indiana is concentrating more and more on the tourist industry ....
>
> "Tourist business brings in four billion dollars a year for the 12 state area and Indiana would be getting $330,000,000 a year if the business was divided equally among the twelve states" (18).

In September, 1961, Governor Matthew E. Welsh at a Ripley County Jefferson-Jackson Day dinner stressed that:

> ". . . Indiana's income from tourists should be increased from $250 million to $500 million. He said the importance of such a step 'increased employment opportunities, higher levels of business activity and greater state and local governmental revenues are obvious.
>
> ....
>
> "He said that increasing tourist business 'is not a partisan matter, it is an effort in which Hoosiers of both parties can and should be interested'" (19).

To summarize. An examination of city, county, state and federal-owned public recreational facilities in Indiana indicates that existing accommodations are totally inadequate for the present population and could not satisfactorily support an expanding tourist industry (20).

Mr. Clawson has estimated that based on anticipated population growth Indiana will need 640,000 acres of state park land (outdoor recreational land) by the year of 2000. In 1960, Indiana owned about 200,000 acres of recreational land (21). Where and how can it get an additional 440,000 acres today?

Suggestions for Outdoor Recreational Expansion

Having presented the *need* for expanding Indiana's public outdoor recreational facilities, the author now asks: "What can and should be done to accelerate expansion?"

Suggestions for improvements may be grouped under the following four headings: (1) surveys and plans, (2) expansion of acreage, (3) expansion of accommodations and (4) administrative changes.

Surveys and plans. Unfortunately, there still is a lack of adequate scientific information on which to base a sound long-ranged expansion program. Some of the surveys that should be made as soon as possible are:

1. A scientific survey of the state forests should be made by recreational specialists. They should prepare a written inventory and appraisal of sites and areas that could be developed. At present, pressure is being brought to bear upon the Department of Conservation and its Division of Forestry to spend thousands of dollars on recreational accommodations before such a survey is made. To build such facilities before such a study cannot be justified. An expansion program based upon guesswork is at best inefficient and wasteful and could prove disastrous.

2. The Division of Parks should make a survey to determine what additional acreage it needs and to locate and appraise potential recreational lands which could be purchased for either state or national parks.

3. A survey should be made of the potential recreational assets which will become available after the construction of a "Chain-of-Lakes in the Ohio River" (22).

4. Surveys need to be made to lay out the routes of potential regional, state and interstate hiking, bicycling and horseback trails, and to determine what additional facilities will be needed before the proposed routes are put into operation. Perhaps one of the first interstate trails could be the old Buffalo Trace or Lincoln Trail which was followed by wild animals, Indians and early white pioneers. This trail leading from Louisville to Vincennes could link with the Kentucky and Southern Indiana trails and those of the Southern Illinois Ozark area. Another trunk trail might be established along the Ohio River between the Markland Dam (upstream from Madison) and Cairo, Illinois. If these two trails were established, a third one might be routed north from Cairo to one now in operation in Illinois which crosses the state from west to east following the Shawnee Hills. By extending the latter trail to Vincennes, a person could make a circle trip through parts of three states. Adaquate hostels and horse barns would need to be planned at convenient stops along these trails.

5. The Tourist Assistance Council of the Department of Commerce, Agriculture, Industry, and Public Relations should make available, as quickly as possible, its basic current project—an inventory of Indiana's tourist attractions. This council does plan to issue a series of bulletins with the masthead "What to See in Indiana" about seven sections of this state (23).

6. A team of "Wilderness Area" experts should be appointed to investigate and turn in a written report concerning the possibilities of legally establishing and protecting remaining "Wilderness Areas" in Indiana.

7. An investigation should be made to evaluate the need for and potential location and development of a state outdoor museum. Such a museum should not be limited to a zoo or standard type "city museum" built in a forest.

8. After the necessary surveys have been made concerning the various phases of the state's conservation problems (which is the wise management of our natural resources), a comprehensive but elastic plan of development (not a straight-jacket one) should be outlined and presented to the public.

Expansion of recreational acreage. Regardless of what criterion one follows, Indiana does not own sufficient land on which to build adequate outdoor recreational facilities. In order to secure several times as much land as the state now owns for such purposes, the writer recommends that:

1. Between 1963-1973, the Indiana General Assemblies should provide at least $2.5 million to be used by the Department of Conservation in creating new parks and enlarging the ones now in operation.

This new money (not money earned by the parks) should be appropriated at the rate of at least $0.5 million per biennium. The money should be spent as opportunities present themselves and need not (but could) be spent before 1980.

2. During this same ten-year period (1963-1973), the Indiana General Assemblies should provide $0.5 million land-purchase fund to be used by the Department of Conservation to enlarge present state forests and/or develop new ones. This money should be appropriated at the rate of $100,000 per biennium, with the understanding that none of it can be used on the purchase of stripped coal mine land or land pitted with quarries. There should also be an understanding that the money could (but need not) remain in the fund until 1980 rather than attempting to spend all of it every biennium.

3. The Indiana General Assembly should at each session pass a joint resolution (by both the house and senate) urging that:

(1) The United States Congress make available $100,000 to $150,000 a year for the purchase of land within the boundaries of the Hoosier National Forest, and,

(2) The recreational sites within the Hoosier National Forest be developed as rapidly as public needs justify them.

4. The Department of Conservation should accelerate its recently initiated program of securing access areas along major rivers and state-owned lakes.

5. The Department of Conservation in collaboration with other state agencies should plan and develop a system of parkways.

6. Officials of Indiana's Department of Conservation in cooperation with the United States Park Service should investigate the possibilities of establishing national parks, parkways and monuments in Indiana. Parkways might be established along the Ohio and Wabash Rivers; along stretches of the pioneer Michigan Road and the road followed by Abraham Lincoln from his Kentucky birthplace to Southern Indiana and to Illinois. United States Senator Vance Hartke introduced a bill in the 1961 Congress of the United States for the creation of a Lincoln Parkway (24).

7. The Indiana General Assembly should pass a bill giving Indiana's Department of Conservation the:

> ". . . power to condemn and acquire land which a utility has taken over by condemnation for a reservoir, but which is left over after the reservoir is established.
>
> "The leftover land now stays in the hands of the utility.
>
> "If the Department of Conservation could acquire it, it could be used for state park, state forest, or other public recreation purposes" (25).

Expansion of accommodations. During the ten-year period (1963-1973) why shouldn't Indiana provide at least 7.5 million for the development of recreational facilities on state-owned land. Perhaps this should be done through the sale of bonds as Kentucky has done.

To repeat that "Indiana has one of the best park systems in the United States" borders on the ridiculous (if not worse) when one learns about the huge park funds made available for this purpose in other states. To mention some of these states and their park funds, they are: (1) California with one hundred million dollars, (2) New York seventy-five million, (3) New Jersey sixty-five million and (4) Wisconsin with fifty million dollars "being raised over a 10-year period with a one-cent cigarette tax" (26).

Administrative changes and action. The efficiency of Indiana's Department of Conservation and in turn the expansion of public outdoor recreation facilities is severely handicapped by poor administrative practices established before 1960. Administrative changes are long overdue. Some of these are:

1. Land owned by the state and managed by the Department of Conservation should be managed by this department as a whole under a policy of *multiple use*, and serviced by the various divisions within the department. At the present time the Frances Slocum, Salamonie, Cagles Mill and Selmier State forests are managed by the Division of Forestry in spite of the fact that these so-called forests are used primarily as recreational areas (as of July, 1960, these four forests contained only 3,078 acres or an average of less than 1,000 acres each). Today these "park-used" areas, labeled state forests, are under the management of the Division of Forestry which does not have a park or recreational specialist on its staff. Would a careful evaluation of the past management show a wise use or misuse of these state-owned properties?

Of course within the department land can be transferred from one division to another. For example, on January 1, 1962, the Wells County State Game Preserve, located east of Bluffton, became Indiana's twenty-second state park and it is now called Ouabache State Park (27).

2. Why shouldn't all state created commissions, agencies, committees and other administrative machinery dealing with conservation be in the Department of Conservation where the activities could be coordinated? This is not true now. For example, few if any can deny that the Department of Conservation is and should be responsible for providing state-owned outdoor recreational facilities. Yet, apparently at first the personnel of this department was not given an opportunity to help plan for the potential recreational uses of Indiana's flood control reservoirs that have been constructed, are under construction, or in the planning stages (18). Why not? Apparently because in some governor's administration in the past the Indiana Flood Control and Water Resource Commission was created as a separate agency and is not a part of the Department of Conservation. Consequently, the Indiana Flood Control and Water Resource Commisison's actions are still not subject to the review of the Director of Conservation nor have they been coordinated carefully with other state programs within the department.

For greater efficiency and harmony, the efforts of various well-meaning private and public agencies need to be coordinated so that money and individual time can be used more effectively. At the present time good intentions, energy and money are wasted in a maze of organizational chaos and political pressure politics which confuse rather than inform harassed elected officials attempting to manage almost insurmountable problems in 60 days.

3. The Department of Conservation needs to be placed under Civil Service.

4. The Director of the Department of Conservation should evaluate carefully the need for and the implementation of a new division within the department to be devoted to long-range planning based on surveys and cooperation with interstate pacts such as the Wabash Compact.

5. Well-trained and educated personnel should be given summer time apprenticeship experience and employment at the state's recreational areas. Director Donald Foltz is initiating such a program and this suggestion is simply offered in support of his action.

6. Pilot Summer Youth Conservation camps for non-penal youth (ages 16-25) who is now deprived of an opportunity for gainful employment should be established.

Each summer there is a tremendous reservoir of youth for which there is insufficient employment. If these youths develop lazy and indolent habits, is it not partly the fault of society which has closed so many doors on work opportunities?

7. Representatives from Indiana's Department of Conservation should meet with similar departmental representatives from Illinois, Ohio, West Virginia and Kentucky to consider individual state water rights to a canalized Ohio River. Construction of high permanent dams is rapidly converting this river into a Chain-of-Lakes which spreads out beyond the river's natural channel. Should representatives from Kentucky continue to block an agreeable water rights settlement on the matter then the other four states should take the problem to the United States Supreme Court.

8. Correlate state outdoor recreational development with regional, county and city programs when opportunities are available. The city of Columbus, for example, has the finest city park program in the state. And just recently Jefferson County officers have initiated an expanding county recreation program.

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Smithville, Amo, and Coatesville

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Most Americans, including those who live in them, believe that our villages are dying, if they are not actually dead. This notion was dramatically presented on the nation's television screens in the Spring of 1962 (1). But contrary to popular opinion, villages in the Middle West, at least, have not been dying, if one defines a village as an incorporated place of less than 1,000 persons which is outside an urbanized area, and if one defines the demise of the village in terms of population decline. In 1960 a nine state area in the Middle West contained almost 4,000 villages, or about two-fifths of the national total. Some 219 of these villages had been incorporated since 1950, and thus no data have been published on their 1950 population (Table I). Of the remaining villages, just over half had more people in 1960 than they had had in 1950, while just under half had lost population. In many villages, however, the gain or loss was so slight that it appears reasonable to assume that the population did not change at all, and I decided quite arbitrarily that a gain or loss of 10 percent or less represented essentially no change in the size of the village population. Viewed in this light, almost a third of the villages gained population, roughly a quarter lost, and almost half remained essentially stable.

TABLE I

Number of Incorporated Places of Less than 1,000 Persons, Outside Urbanized Areas, by Rate of Growth, 1950-1960

	Nine Middle Western States		Indiana	
	Number	Percentage	Number	Percentage
Total number	3,943		275	
Incorporated since 1950	219		11	
Remainder	3,724	100.0	264	100.0
Plus 10% or more	1,106	29.8	101	38.2
Plus 0-9.9%	880	23.6	72	27.3
Minus 0-9.9%	839	22.5	60	22.8
Minus 10% or more	899	24.1	31	11.7

The fact of village growth was even more impressive in Indiana, where two-fifths of the villages grew more than 10 percent, and only one in ten lost more than 10 percent of its population, while two-thirds of the villages in the state experienced some growth in population during the decade.

The continued, and generally unsuspected, growth of our villages necessitates re-examination of a number of stereotypes which have been based on the assumption that villages are fading away. Doesn't the village population consist largely of widows and retired farmers? Isn't the village merely a "fished-out pond" consisting almost entirely of people who remain there simply because they have lacked the initiative to leave? Would young couples actually be willing to live and raise their families in a village? And what do the village people do for a living?

A research program to provide answers to some of these questions was initiated during the first Big Ten Faculty Field Research Seminar, held at Gull Lake, Michigan, in early September 1961, when two villages in southern Michigan were investigated in some depth. The questionnaire used in this pilot study was subsequently refined, and it has been used in a series of village investigations in Indiana, Iowa, Illinois, and Wisconsin. The author shares the direction of the larger village research project, of which this paper is a partial product, with Professor Neil E. Salisbury of the State University of Iowa, whose counsel has been of the greatest value. The data presented here were collected by graduate students at Indiana University who were enrolled in Geography G502, Field Methods, in the Spring Semester, 1962; the author expresses his appreciation to Joyce Kyei, Harry Margulis, John Ntimba, Jerry Poling, Dale Stevens, Charles Tatum, and James Wheeler for their conscientious efforts and constructive suggestions. This paper presents data gathered, and some tentative conclusions reached, in the investigation of three villages in Indiana.

Smithville, about 7 miles south of Bloomington in the southern Indiana limestone belt, is not properly a village as we have defined it, for the community is not incorporated; the 1962 population was estimated to be about 340 persons. Smithville was chosen as an example of an unincorporated village in a limestone quarrying area, and also because of its proximity to a city of medium size (Bloomington; 1960 population, 31,357).

Amo and Coatesville are 27 and 32 miles, respectively, west of Indianapolis, and 13 and 16 miles east of Greencastle; both villages are on paved secondary roads about 5 miles north of four lane U. S. 40. The population of Amo has grown continuously since 1920, when it had 274 people, to 1960, when it had 437. Coatesville grew from 472 persons in 1910 to 522 in 1920, then dropped to 377 in 1940, and grew once again to 497 in 1960. Both Amo and Coatesville grew more than 10 percent between 1950 and 1960.

Smithville and Amo both give a subjective impression of decline. Several years ago a fire destroyed the ramshackle structure housing Smithville's only general store, which now struggles along in a former private residence. Amo likewise has only one general store, and it does not appear to be suffering any great surfeit of prosperity either. The feeling of decline in both villages is reinforced by the fact that more than half of the houses in each were estimated to have been constructed before the First World War (Table II).

Coatesville has almost as high a proportion of older houses as the other two villages, and like them has one house in four which has been built since 1944, but its business district is much more modern and gives

TABLE II

Questionnaire Results from Indiana Villages, 1962
With Estimates for Indiana and the United States, 1960, for Purposes of Comparison

	Smithville		Amo		Coatesville		Indiana	United States
	Number	Percentage	Number	Percentage	Number	Percentage	Percentage	Percentage
Year in which the house was built								
Number of houses	100	100	107	100	134	100	100	
1913 or before	53	53	64	60	62	46	40	
1914-1944	23	23	15	14	39	29	25	
1945 or later	24	24	28	26	33	25	35	
No response								
Number of houses	100	100	107	100	134	100		
Vacant	5	5	1	1	4	3		
Nobody at home	27	27	21	20	46	34		
Refused to answer	12	12	9	8	18	13		
Age of the population in households interviewed								
Total population	188	100	283	100	218	100	100	100
0-19	65	35	96	34	62	28	39	38
20-34	53	28	83	29	64	29	19	19
35-64	49	26	80	28	58	27	34	33
65 and over	21	11	24	9	34	16	9	9
Size of the family in households interviewed								
Number of families	56	100	76	100	66	100	100	100
1-2 persons	8	14	14	18	16	24	41	42
3-4 persons	26	47	29	38	27	41	37	36
5 or more persons	22	39	33	44	23	35	22	22

an impression of prosperity in contrast to the apparent stagnation of Smithville and Amo. In actual fact, however, the appearance of Coatesville is deceiving, for it is a product of catastrophe, not prosperity; much of the center of the village was destroyed by a tornado in 1948, and new modern buildings were erected with insurance money.

By the time we had completed our interviewing, in fact, our initial impressions had been reversed. Coatesville, which had initially appeared the most attractive and progressive of the three villages, was considered the most provincial and backward of the three. Our conclusions here strongly support Mather's warning on the danger of basing field work solely on morphological observations, without interviews to substantiate the impressions gained from these observations (2).

Interviews were conducted in Smithville and Coatesville on Saturday mornings, and in Amo on Saturday afternoon, but we are not prepared to suggest that this fact alone accounts for the higher response rate in Amo. A remarkably small fraction of the houses in the three villages were vacant, but a fifth to a third had nobody at home when the interviewer called. Roughly one household in every eight flatly refused to answer our questions. Our rate of response ranged from 50 percent in Coatesville to 70 percent in Amo.

We found an astonishingly high proportion of young adults, aged 20 to 34, in each of the three villages, and have been somewhat surprised that this concentration of population in the child-bearing years was not matched by a concentration in the childhood years, aged 0 to 19. This is doubly puzzling because of the comparatively large number of large families, with five or more persons. On the other hand, the percentage of the population aged 65 and over appreciably exceeded the national norm only in Coatesville, and neither Smithville nor Amo fit the stereotype of a village consisting largely of elderly widows and retired farmers.

Almost half of the families interviewed reported that they have lived in the village since the family was formed, although movement from house to house within the village has not been uncommon (Table III). Roughly a quarter of the families in each village moved to the village from a farm, and the remainder came to the village from another village or from a town or city. Contrary to popular notions, however, only Smithville received more "immigrants" from urban areas than from farms, and Smithville is a mere seven miles from Bloomington. The continued growth of Amo and Coatesville appears to have been nourished primarily from within, from surrounding rural areas, and from other villages, sometimes at surprising distances. In both Amo and Coatesville, for example, we encountered families which had moved to Indiana from farms or villages in other states because the family breadwinner had obtained a job in a city nearby, but the family had rejected the idea of living in that city and had preferred to live in the village instead.

More than half of the families in Amo had lived there less than five years, and three-quarters had lived there less than ten. Recency of arrival was not quite so pronounced in Smithville and Coatesville, and yet even here roughly half of the families had been in the village ten years or less. This may not be as surprising as it seems, in view of

TABLE III

Questionnaire Responses Concerning Migration to Indiana Villages, 1962

	Smithville		Amo		Coatesville	
	Number	Percentage	Number	Percentage	Number	Percentage
Where did your family live before you moved to this house?						
Number of respondent families	56	100	76	100	66	100
Always lived in this house	11	20	9	12	15	23
Another house in this village	15	26	24	32	15	23
On a farm	12	22	19	25	18	27
In another village	4	7	12	15	9	13
In a larger place	14	25	12	16	9	14
When did you move to this village?						
Number of respondent families	56	100	76	100	66	100
Less than 5 years ago	15	27	44	58	24	36
5-10 years ago	15	27	14	18	8	12
More than 10 years ago	26	46	18	24	34	52
Why did you move to this village?						
Number of respondent families	56	100	76	100	66	100
Born here	21	38	26	34	25	38
To be close to family/friends	7	13	11	15	7	11
Larger/cheaper house	12	21	7	9	8	12
Found a job locally	8	14	13	17	12	18
Other	8	14	19	25	14	21

the presence in all the villages of comparatively large numbers of young married couples whose marriages have been formed for less than ten years, but neither is it compatible with the stereotype of the village as a "fished-out pond" with little attraction for non-villagers, and especially little for young married couples!

The reasons given for moving to the village were rather diverse. A third of the families were here because one spouse, or both, had been born here, and more than ten percent of the families had moved here—most commonly from adjacent rural areas—because the village was part of their native community of family and friends. Although some of these were retired farm families, the group also included relatively young families which had decided to give up farming for some other occupation, but which wished to remain in the native community. The capital invested in village houses, which commonly are both large and surprisingly cheap to buy or rent, was also an attraction to former farm families. The roominess and cheapness of village housing was especially attractive to Bloomington workers in the lower income brackets, and a fifth of the residents of Smithville gave this as a reason for moving here. Job opportunities were of little more importance than ties of friendship and kinship in attracting newcomers to the villages. This is partially due to the limited economic opportunity of the village, although many of the "local" jobs which attracted people to the village could be considered local only in the very loosest sense; jobs more than 25 miles away in Indianapolis, for example, attracted Kentucky people who preferred village life to braving the perils and temptations of the big city, and these people truthfully informed us that they had moved to the village because they had found a job locally.

What did they do for a living? All three villages had more than their share of retired people, but only Coatesville (with 28 percent of its labor force in this category) truly seems to fit the stereotype of the village as consisting primarily of retired people (Table IV). Each village had less than the national percentage of its labor force engaged in the service occupations, and only Amo approached the national percentage of white collar workers, while each village had more than its share of skilled and unskilled workers.

The places where its residents are employed provides a fairly convenient summary of the nature of the three villages. Smithville, in the limestone quarrying belt, is essentially a dormitory village for quarry workers who are employed in the surrounding countryside, and for blue collar workers employed in Bloomington. Amo is a dormitory village for Indianapolis, 27 miles away, although it is so close to U. S. 40 that it provides a convenient base for traveling men who are free to select a residence over a fairly large territory. The dormitory function, for both Indianapolis and Greencastle, is of some importance in Coatesville, but Coatesville is also a village of many elderly and retired people, and a sizable proportion of the village labor force is locally engaged in serving their needs. This, in addition to the benefits of tornado insurance, appears to explain the greater economic activity of Coatesville, the activity which made such a favorable first impression before we had probed beneath the surface.

TABLE IV

Characteristics of the Labor Force in Indiana Villages, 1962

	Smithville		Amo		Coatesville		Indiana	United States
	Number	Percentage	Number	Percentage	Number	Percentage	Percentage	Percentage
Total Labor Force	71	100	87	100	74	100	100	100
Retired	12	17	15	17	21	28		10
Unemployed	4	6	2	2	0	0		6
Employed Labor Force	55	77	70	81	53	72		84
Major Occupation Groups								
Employed Labor Force	55	100	70	100	53	100	100	100
Professional/Managerial	4	7	13	19	9	17	18	22
Clerical/sales	3	5	14	20	9	17	21	21
Craftsmen/foremen	13	24	22	31	16	30	15	13
Operatives, etc.	29	53	18	26	14	26	28	23
Service workers	6	11	3	4	2	4	11	13
Farm	0	0	0	0	3	6	7	8
Place of Employment								
Employed Labor Force	55	100	70	100	53	100		
In the village	10	18	15	22	20	38		
On a farm	0	0	0	0	3	6		
In the country nearby	16	29	1	1	0	0		
In a larger place	27	49	44	63	29	54		
Travelling	2	4	10	14	1	2		

In conclusion, our survey did find signs of the traditional stereotype of the village, but it appears that the stereotype has been considerably exaggerated. The villagers were not so elderly as we might have expected, and we found that the villages are continuing to attract young families who, for the most part, have farm or village backgrounds and prefer life in the small community to life in complex urban society. Although they have few of the economic functions which are supposed to maintain the viability of central places, the villages do have one very great asset in the capital invested in their houses, and the continued growth of villages in the Middle West suggests that not enough attention has been paid to the dormitory function as one of the basic functions which supports and maintains population growth in small central places.

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The Relative Relief of Monroe County

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It is the purpose of this paper to study the relative relief of Monroe County, Indiana in relation to the regional physiographic units which cross the county.

The first step was the preparation of a map of relative relief of Monroe County. The relative relief of each of the 422 square mile sections within the county was determined from United State Geological

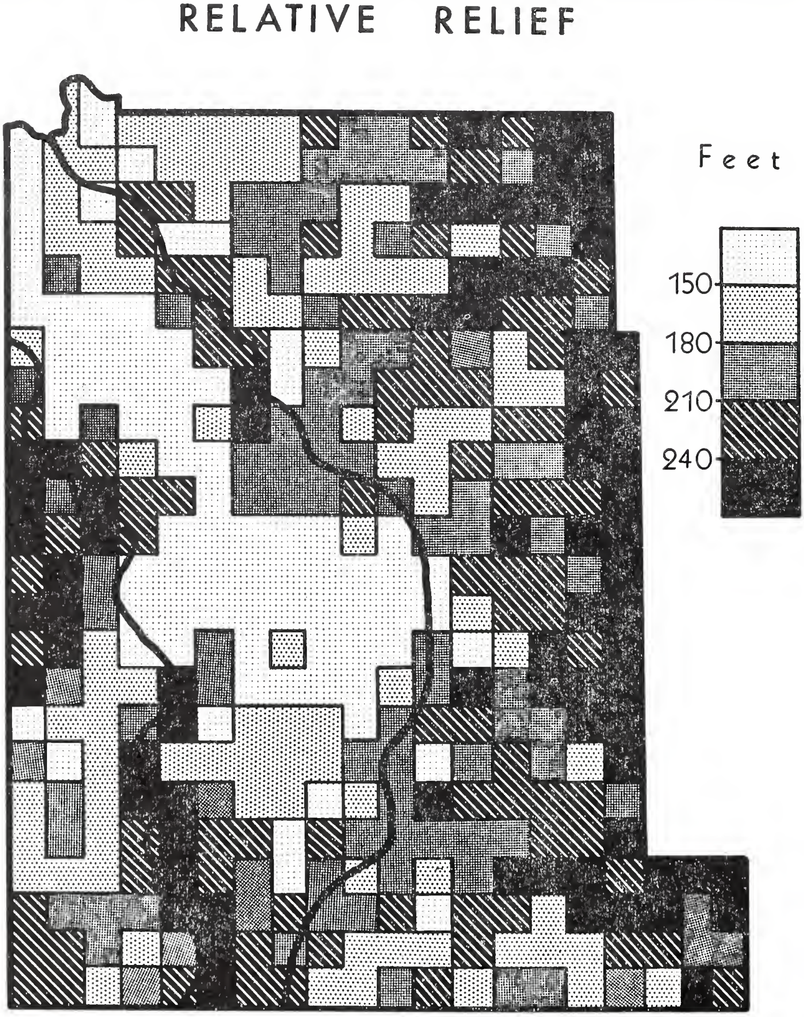

Figure 1. Relative Relief Map of Monroe County.

Survey topographic sheets Fig. 1. These data were plotted on the base map provided by the General Highway and Transportation Map of Monroe County, prepared by the State Highway Commission of Indiana.

Since a smaller area might be expected to have less relative relief than a larger area, two basic procedures were used in the preparation of this map in order to avoid determination of the relative relief of sections less than one square mile in area. The four sections in the extreme northwest section of the county bounded by the west fork of White River were considered in their entirety. Considering only the portion of each of these townships southeast of the river (i.e. in Monroe County) would have conveyed a distorted conception. For the same reason sections 6, 7, 18, 19, 30, and 31, in the northeast portion of the county which are less than a square mile in area were combined with adjacent sections to the east and west in the determination of the relative relief of six sections of only one-half square mile. The boundary line was then drawn dividing these sections into equal parts, half to the east and half to the west, attached to their respective adjoining sections. Some sections are shown as being less than one square mile because of correction lines. The pattern shown on this map also assumes that all section lines in the county appear as straight lines meeting at right angles while in fact, they do not.

In order to determine the relative relief of all of the sections of the county, it was necessary to use sixteen topographic sheets at a scale of 1:24,000 prepared by the Geological Survey. These sheets as titled on the current Geological Survey Index Map to Topographic Mapping in Indiana are: Hindustan, Modesto, Gosport, Morgantown, Belmont, Unionville, Bloomington, Whitehall, Elkinsville, Allens Creek, Clear Creek, Stanford, Norman, Barlettsville, Oolitic, and Owensburg. As the relative relief of each section was determined it was recorded in its respective section on the base map.

The next step was to prepare an array of these figures and determine the number of times each occurred. The range of relative relief in the 422 sections in Monroe County was between 60 feet and 350 feet. The most frequently occurring relative relief was 240 feet. Also common were 170 and 200 feet. A map based solely upon the relative relief in feet showed only 9 sections of the county with relative relief of under 100 feet and, only eleven of 300 feet or over. Thus, the majority of the land in Monroe County has relative relief between 100 and 300 feet.

The next step in the preparation of the final map was to divide the total number of sections of the county into quintiles in terms of the array of relative relief values. The boundaries of the three physiographic provinces of Monroe County—the Crawford Upland, the Mitchell Plain, and the Norman Upland were superimposed on the map of the relative relief (1).

In the central and northwestern portions of the county the Mitchell Plain coincides with the area of lowest relative relief but the southern portion of the Mitchell Plain, which is dissected by Clear Creek and its tributaries, has greater relative relief, including some of the most extreme relief in the county. The escarpment of the Crawford Upland is clearly evident along the western border of the map but interior portions of the Crawford Upland have rather slight relief. In the Norman Upland relative relief increases in an easterly direction away from the Mitchell Plain.

This map bears evidence that the relative relief of Monroe County reflects, to some extent, the geologic character of the county and the physiographic provinces which cross its boundaries. It is hoped that this paper will be merely the first of a series of studies of relative relief in other Indiana counties. A relative relief map of the entire state compared to the physiographic sub-provinces of Indiana would be an appropriate subject for future research.

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HISTORY OF SCIENCE

Chairman: NED GUTHRIE, Hanover College
A. T. GUARD, Purdue University, was elected chairman for 1963

ABSTRACTS

Chemical Research Publications by Alumni of Hanover College. NED GUTHRIE, Hanover College.—This study covers the years 1880 through 1961, a total of 82 years. Only graduates of Hanover College are included in the list which is available in book form. Only publications in chemical journals are included in the chemical list or it has been abstracted in chemical abstracts if published in a non-chemical journal. In the second list are those articles not abstracted in chemical abstracts. In the number of publications in the table, the nonchemical number is placed in parenthesis.

In all there are listed 597 different chemical publications and 96 nonchemical making a total of 693. Of these chemical publications, 122 were by Dr. Harvey W. Wiley, 160 by students of Dr. A. H. Young who was on the faculty of Hanover College from 1879-1926, and 315 by my former students. Approximately one half of the chemical research publications have been made since the end of World War II.

Biographical Sketches of Indiana Scientists, III. JOSEPH TINGLEY, WILL E. EDINGTON, DePauw University.—Joseph Tingley was one of that group of scientists, Daniel Kirkwood, Ryland T. Brown, John L. Campbell, Edward T. Cox, Richard Owen, who were most active and influential during the period 1850 to 1880. Tingley was born in Ohio in 1822 and was a cousin of Matthew Simpson who in 1839 became the first president of Indiana Asbury University, now DePauw University. Tingley graduated from Indiana Asbury in 1846 and was Professor of Natural Sciences at Indiana Asbury University from 1849 to 1879. He was a licensed Methodist minister and an excellent musician. During his career he taught courses in Chemistry, Physics, Botany, Zoology, Geology and Astronomy, and also practiced engineering. An excellent lecturer he appeared before Teachers' Institutes, meetings of scientific groups, Chautauquas, etc., and was President of the Indiana State Teachers Association in 1868. He was probably the first in the State to lecture on and demonstrate the arc light before an Indianapolis audience. After leaving Indiana Asbury University he became Professor of Natural Science in Central Normal College in Danville, Indiana, President of Marion, Indiana, Normal College, Civil Engineer for the Kansas City Cable Railroad, and at the time of his death in 1892 he was Professor of Metaphysics and Science in Campbell Normal University, Holton, Kansas.

Indiana's Yield of Eminent People Compared with that of Nearby States

STEPHEN S. VISHER, Indiana University

This study was instigated partly by a comment by Elmer Davis (1890-1958) in his excellent discussion of Indiana at the celebration in Washington, D. C., of the 140th anniversary of statehood. This highly distinguished Hoosier-born journalist, newscaster, and public official observed that Indiana had produced many high-class second-rate men but very few first-rate ones. He wondered why. Indiana has been for more than a century one of the more populous of the states, ranking from sixth to twelfth, one of the more prosperous states, and in many respects one of the most fortunate. In 1962 a much-publicized federal declaration that Indiana has received recently notably less than its due share of federal contracts and grants "because it does not have its share of highly competent men," has focused attention upon this problem.

Long recognized has been the fact that many of our more capable people have left the state because better opportunities for them were available elsewhere. This is true, for example, of the two Hoosiers who have won Nobel prizes, W. M. Stanley and H. C. Urey, chemists, and of those elected to the National Academy of Sciences, and most of those starred in *American Men of Science.*

The present study started with geologists and geographers. The Geological Society of America has been recognized almost since its inception in 1889 as a world leader, and its presidents are distinguished men, practically all members of the National Academy of Sciences. Indiana was the birthplace of only one (C. P. Berkey), while Ohio yielded 5; Missouri and Minnesota, 3 each; Illinois, Wisconsin and West Virginia, 2 each; and Kentucky, Tennessee and Iowa, one each; and Ontario, 5. Moreover the one born in Indiana left the state as a boy. By contrast Ohio, Michigan, Illinois, Missouri, Wisconsin, and Minnesota each not only yielded one to several of these eminent people but their universities graduated and employed two or more of them for lengthy periods.

The Association of American Geographers, established in 1904, was until 1948 somewhat comparable with the G.S.A. although less distinguished. No native of Indiana has been president of the A.A.G. and only one native has been vice-president (C. M. Zierer, I.U. '22, '23). By contrast, Kentucky was the birthstate of 2 A.A.G. presidents; Ohio of 4 presidents and 3 vice-presidents; Michigan of 6 presidents and 3 vice-presidents; Illinois of 5 presidents and 6 vice-presidents; Wisconsin of 2 presidents and 3 vice-presidents; and Minnesota and Missouri each of 2 presidents; and Iowa and Ontario each of one.

Combining the number of presidents of the G.S.A. and presidents and vice-presidents of the A.A.G. born in each state, the totals are: Indiana 2, Kentucky 3, Missouri 5, Ohio 12, Illinois 13, Michigan 9, Wisconsin 7, Minnesota 5, Iowa 2, Ontario 6.

Supplementary to these studies of eminent geologists and geographers, several other types of notables were studied: No native of Indiana has been *president of the United States* whereas 7 natives of Ohio have been, and one each of Kentucky, Missouri and Iowa. Even more significant, because larger numbers are involved, and the lack of fortuitous circumstances often involved in the election of presidents of the United States, are the *presidents of the American Association for the Advancement of Science:* No native of Indiana has been president of the AAAS, while Ohio yielded 11, Michigan 4, Illinois 6, Kentucky 2, Missouri 1, and Ontario 2. No native of Indiana, born since 1820, has been *president of the American Bar Association* (George Wright, 1887). Only three Hoosiers have been presidents of the *American Historical Association* (Edward Eggleston, 1900; C. A. Beard, 1933; James G. Randall, 1952). Illinois yielded 5, Ohio 3, Iowa 2, Wisconsin 3. Of the *American Chemical Society*, Indiana yielded only one before 1939 (Harvey W. Wiley, 1893) but 5 since then (Charles A. Kraus, 1939, W. A. Noyes Jr., 1947; E. C. Britton, 1952; John C. Warner, 1956; Arthur Cope, 1964). Ohio yielded 5, Illinois 5. Of the *Ecological Society of America*, Indiana yielded 3 (C. Juday, 1927; W. C. Allee, 1929; S. A. Cain, 1958), Illinois yielded 6, Michigan 4, Ohio 4, Iowa 3, Nebraska 3, Minnesota 2. Of the *American Physical Society* Indiana yielded 2 (E. Merritt, 1914; L. A. DuBridge 1947), Ohio yielded 8, Illinois 3, Michigan 2, Wisconsin 1, Iowa 1. Of the *American Botanical Society* Indiana yielded 2 (C. A. Barnes, 1903; J. R. Schramm, 1925). Michigan yielded 9, Illinois 3, Wisconsin 3, Nebraska 2, Ohio 1. Of the *American Psychological Association*, Indiana yielded 6 (W. L. Bryan, 1903; Lewis Terman, 1923; J. F. Dashiell, 1938; D. W. Allport, 1939; C. P. Stone, 1942; and E. L. Kelly, 1955). Illinois yielded 6, Ohio 4, Nebraska 4, Minnesota 1, Iowa 1. Of the *American Society of Zoologists* Indiana yielded 5 (Jacob Reighard, 1903; C. Grave, 1928; Fernandus Payne, 1931; W. C. Allee, 1936; V. C. Twitty, 1959). Illinois yielded 8, Ohio 4, Michigan 3, Iowa 3, Wisconsin 1, Nebraska 1. Of the *National Education Association* Indiana yielded 8 (J. Swain, 1914; Robt. Aley, 1917; J. H. Newlin, 1925; Henry Lester Smith, 1935; O. C. Pratt, 1936; Donald DuShane, 1940; Edith Joynes, 1943; Robert Wyatt, 1963). Illinois yielded 7, Ohio 7, Iowa 2, Minnesota 1, and Missouri 2.

These various totals of the far greater yield of eminent people from states near Indiana than from Indiana prove that Indiana, despite its advantages, has unquestionably failed to produce its share of outstanding men. Why? In population totals, Indiana has been surpassed among these states only by Illinois and Ohio and they only slightly and recently. Its average per capita income has been above, and its agricultural and other natural resources are comparable with those of these other states. It has had several high-quality institutions of higher learning.

The data given in this article clearly substantiate Elmer Davis' observation that Indiana has yielded few first-rate men. He rightly wondered why. My 44 years of study of Indiana and its more notable people (including a volume *Indiana Scientists* published by the Academy) permit me to list contributing factors.

Highly significant is the smaller percentage of Indiana's people who are seriously interested in scholarly achievement. Unfortunately there is an excessive amount of interest in basketball, football, local politics, fraternities, sororities, local clubs, and local prestige. Few people in Indiana care earnestly for more than prompt victories and local recognition. Many even "leading citizens" think that people who are sketched (because of their achievements) in *Who's Who in America,* for example, are "queer," and most Hoosiers almost scorn people who win wide recognition. What counts with most Hoosiers is local recognition or materialistic successes. These ideals are held widely in other states, but somewhat less universally in states near Indiana than here.

The financial support of Indiana's state universities and colleges has been conspicuously less generous than that received by the state institutions of nearby states. This fact reflects a lesser appreciation on the part of key members of the legislature of the great value of higher education and of the great value to Indiana of affording excellent higher education to those qualified. The fact that most of the especially talented young people leave Indiana to accept positions where their talents and skills are better recognized and rewarded is a really serious loss to Indiana.

What can we individually do to improve Indiana's standing? As suggested in my address as president of the Academy, and elsewhere, we should strive more actively to encourage young people and our fellow workers, and should do what we can to increase respect for Indiana, its educational institutions, and especially scholarly endeavors. Encouragement to be effective requires opportunities. Words are not enough.

A Century and A Quarter of Geology at Hanover College

S. C. Adams, Hanover College

Geology at Hanover has shared well in the rich scientific tradition on this campus. As is true everywhere, natural science has steadily become more diversified and more highly specialized. Therefore, in tracing back the story of geology here, that subject necessarily converges with that of the other sciences.

We are proud of the record of our college in science. Such a history deserves explanation and analysis. Probably there are many factors responsible. Some of them are apparent in the history of the college, but others are to be found only by digging below the roots of our 1827 origin. Such, for example, is the great work in science done at Transylvania College in the first quarter of the last century under the leadership of such scholars as Constantine Samuel Rafinesque who has been called by Donald Culross Peattie, "the only titan" amongst all the naturalists who have ever worked on the American continent. Rafinesque had a close bond with the New Harmony scientific center of America in those years. With such an intellectual environment, Transylvania was often referred to as the "Oxford of the Backwoods." From this atmosphere came Dr. Crowe to found Hanover College and to become the grandfather of the Coulters, John M. and Stanley, two of the brightest stars in our constellation. Our first President, James Blythe, was at one time Professor of Chemistry and President of Transylvania. Such men as Crowe and Blythe brought to Hanover some of the enthusiasms for scientific study that prevailed there. These influences and many others, some known and some perhaps lost or omitted from the chronicles, explain the unusual emphasis on science here.

The history of Hanover College covers a period of 135 years and 130 of these have witnessed the presentation of courses in geology.

Beginning in 1832 with a course in minerology for seniors, taught by the professor of mathematics and natural history, continual expansion has led to the present department to which two staff members devote their full time.

For sixty years following the introduction of geology to the curriculum and during the period when most science was undifferentiated under the general head of natural history and natural philosophy, geology was usually taught for one to three terms to juniors and seniors, the time allotted for the subject being determined by the training and interest of available professors and by administrative policies. However, the importance of science in our program has always been recognized and the scientific personnel of the faculty has been outstanding. In the program of science, geology has been favored from the first due in part to the location of the college favorable to its study in the field. During the early decades of its growth, the work in geology was based largely upon the text books of Dana, Hitchcock and Lyell. In 1858 physical geography was presented for the first time, but the presentation of this subject has not been continuous since then.

The first professional geologist to appear at the college was Frank H. Bradley who was brought from Yale to establish a paleontological museum here in the late sixties. Upon the completion of that work in 1869, he was made professor of natural history. Although a brilliant scientist and an able teacher, he lacked tact and was discharged by the board of trustees because of his disagreement with the Mosaic account of the creation. Previous to his arrival at Hanover he had served the Illinois Geological Survey and the early Cox Survey of Indiana. Upon his departure from Hanover, he joined the Hayden Survey of the west, taking his student, John Coulter, along as an assistant. When the Hayden Survey was expanded a few years later Bradley led one division through the Snake River country and to Puget Sound. On this latter expedition, John M. Coulter served as Botanist. When Bradley was killed in 1879 in a Georgia gold mine, he was only 40 years old, yet had attained the highest rank among American geologists. The 1906 "Contributions to the History of American Geology" by George P. Merrill gives him considerable space in a volume that considers a relatively small number of foremost geologists. Both John M. Coulter and his brother, Stanley Coulter, have credited a great deal of their inspiration in science to Bradley. John M. Coulter returned to Hanover as professor of Natural Science and Astronomy from 1874 to 1879. Later he served Wabash College and Indiana University and finally was called to head the Botany Department at the University of Chicago. There his tenure almost coincided with that of T. C. Chamberlin in Geology. During that era Coulter's interest in geology led to close bond between the two departments. The work of some students was so evenly balanced between the two fields that they had a choice in the department from which they received a doctorate.

Bradley was followed in 1870 by Professor E. Thompson Nelson, another Yale man, and in this period geological work for seniors was expanded to include summer field work.

In 1893 under the leadership of Glen Culbertson, geology became a separate department and sufficient work was offered in the subject to prepare students to go ahead professionally in the science. During the 34 years of service which Professor Culbertson gave to Hanover he was compelled to divide his time between geology, his main interest, and physics and astronomy; nevertheless, he trained many good geologists while at the same time gaining a reputation himself as a geologist and serving the interests of Indiana geology on surveys and in research. Among his more outstanding students were his son, Dr. Archer Culbertson, now an executive and from 1948 to 1954 Chief Geologist of the Continental Oil Company, and Dr. Ira Allison, Professor of Geology at Oregon State University, and co-author of one of the most widely used college textbooks. The first full-time professor of Geology was Alfred T. Navarre.

After one year he was succeeded by Grant T. Wickwire who served until his retirement in 1961. The departmental staff was increased to two in 1945 with the addition of the speaker. In 1961 Dr. Joseph L. Weitz was appointed as associate professor. Upon his return to Colorado State University he has been replaced by Dr. Stanley M. Totten.

Since the construction of Goodrich Hall in 1947 our department has been adequately housed and equipped on the first floor of that building.

The department in addition to meeting the needs of the liberal arts student in laboratory science offers an undergraduate major and endeavors to offer to the non-science student an introduction to the services of the profession to our culture. We also assist outside institutions and individuals who are interested in the geological phenomena of the local area.

Hanover has participated in many of the activities of the geological societies. The first formal meeting of a learned society on the campus following the construction of a new group of buildings after World War II was the Annual Meeting of the National Association of Geology Teachers in 1948. In 1962 Dr. Weitz was a participant in the American Geological Institute's foreign institute in the Alps. The geological facilities and program were inspected and evaluated in 1958 by Kirtley Mather of Harvard and Richard F. Flint of Yale under a grant from the Lilly Endowment.

Also in recent years we have brought several prominent geologists to the campus. These include Dr. Robert Black of the University of Wisconsin and Dr. Donald Gorsline of Florida State University.

In addition to the classrooms, laboratories and library maintained by the department, we have a museum which attracts much favorable attention. This present display is mainly the work of Guy Campbell, one of our own graduates who served as curator from 1949 to 1955. A bronze plaque is currently being placed in this room dedicating it to Bradley, who built the original museum on the minerological collection started in 1848, and to Campbell. The collections are presently being expanded and facilities for display increased.

The department has never been, and there are no plans to make it in the future, a large one. However, at present our enrollment of 79 in the introductory course in physical geology gives us second place among the science department of the college in the size of beginning science courses Among our alumni are four who have earned the Ph.D. degree and one more is now a doctoral candidate. Others have received the master's degree. The number of Hanover graduates who may be considered as professional geologists now number about twenty-five.

MATHEMATICS

Chairman: JOHN YARNELLE, Hanover College
ERNST SNAPPER, Indiana University, was elected chairman for 1963

ABSTRACTS

Bi-angular coordinates: The N-Sectrix. MYRON EFFING, Evansville College—Pairs of numbers (η, ι) are shown to locate points in a plane by use of a primary coordinate system in which η and ι are angles. The equation of the first degree in these variables, $\eta = m\iota + \emptyset$, plots curves which divide any angle in 1/m parts, where m is called the index, if $\emptyset$, the deferent, is available. If the index can be expressed as a ratio in lowest terms, graphing is easily accomplished. A set of conversion equations to rectangular and polar coordinates enables the author to derive the circle, the Trisectrix of Maclaurin, the Trisectrix, Freeth's Nephroid, and Freeth's Supertrisectrix if the deferent is zero and the index takes the values ½, ⅓, ⅔, ¾, and ⅚ respectively. Because many more curves can be written out in rectangular coordinates to trisect the angle and to fractionize an angle in any manner whatever, the first degree equation is called the "N-sectrix."

An Introduction to the Stability of Differential Equations. JAMES C. LILLO, Purdue University.—The use of the equation of first approximation for studying the stability of a bounded solution of a nonlinear differential system. Associated problems for nxn variable matrices arising from this approach to the stability problem. The use of a Liapunov function in studying the stability of a solution of a differential equation.

PHYSICS

Chairman: R. T. DUFFORD, Evansville College
PAUL BENDER, Goshen College, was elected chairman for 1963

ABSTRACTS

Angular Distribution of Alpha Particles Scattered by Carbon as a Function of Energy. RICHARD A. ATNEOSEN and HOWARD L. WILSON, Indiana University.—The elastic and inelastic scattering of α particles by carbon has been observed at bombarding energies of 20.16, 20.46, 20.91, 21.20, 21.62, 21.90, 22.48 and 22.73 Mev. Angular distributions have been extracted for the groups corresponding to elastic and inelastic excitation of C^{12} to the 4.43 Mev level in order to study a previously reported anomaly at 21.85 ± .1 Mev. The elastic distributions have a pronounced diffraction structure which varies slowly with energy at the forward angles but shows an anomalous behavior at the back angles. The 4.43 distribution qualitatively obeys the Blair phase rule at the forward angles.

The Beta Decay of Carbon 10 and the Cluster Model of the Nucleus. F. J. BARTIS, Indiana University.—A new toroidal spectrometer has been used to determine an end point of 1865 ± 15 keV for the main positron branch from the decay of C^{10}. Also, the half-life of C^{10} was found to be 19.27 ± 0.08 sec. The C^{10} end point, together with previous work on the mass-10 nuclei, leads to 4.61 MeV for the Coulomb energy difference between C^{10} and Be^{10}. According to the cluster model of Wildermuth and Kanellopoulos, this Coulomb difference is just the electrostatic energy of the diproton cluster in C^{10}. In order to obtain a lower bound on the size of the diproton, we have used the deuteron cluster in Li^{6} which has been cited to explain the 2.80-f charge radius of Li^{6}. Using a cluster model wavefunction and an approximate method suggested by Thieberger, we calculated 3.52 MeV as an upper limit on the C^{10}-Be^{10} Coulomb energy difference. Hence, we conclude that the cluster model is inconsistent with experimental evidence in its description of the spatial properties of these nuclear clusters.

A Study of the Splitting of the Nuclear Quadrupole Resonance Lines of Certain Nuclei in a Weak Zeeman Field. KENNETH S. ROBINSON, Oakland City College.—Single crystals of sodium chlorate, paradichlorobenzene, and cuprite were subjected to bursts of rf energy at their resonance frequencies, and the resulting absorption lines were viewed on the screen of an oscilloscope. Stereographic plots of the splitting pattern in a 10 to 20 gauss field were made, and the field gradient orientations in a unit cell of the crystal deduced from this splitting pattern. These results were compared with similar results obtained from x-ray diffraction, and with results of nuclear quadrupole resonance work carried out in much stronger fields by Dean, Bersohn, Williams, and others. The magnetic moment of the chlorine-35 nucleus was computed from the splitting data.

Beer's Law with a Limited Detector. HAROLD K. HUGHES, Indiana State College.—The exponential law for the absorption of radiation and of particles passing through matter is applied to the measurement of cross sections and to the determination of concentrations in analytical spectroscopy. In these applications it is desirable to choose the uncommitted experimental parameters so as to achieve the maximum sensitivity to changes in cross section or concentration. With a linear detector, the optimum transmittance is generally 1/e or 36.8%. With a limited detector, however, the transmittance should be quite different and may be as low as 2%.

Shape of the $0^+ \rightarrow 0^+$ Positron Spectrum in Ga^{66}. D. C. CAMP and L. M. LANGER, Indiana University.—A detailed study of the beta spectrum of Ga^{66} with emphasis on the shape of the positron spectrum of the $0^+ \rightarrow 0^+$ transition has been made with a magnetic spectrometer. The ground state to ground state transition is found to have a nonstatistical shape. The shape factor is fitted by the equation $S(W) = K(1 + 0.0328W + 0.354/W - 0.000419W^2)$ where the numerical coefficients are explicitly determined by the value of the ratio of the nuclear matrix elements, $\lambda = \frac{< i\,\alpha \cdot r >}{< 1 >} = -21.3$. An additional factor of the form $(1 + 0.4/W)$ is needed to obtain the best fit. The nonstatistical shape for this group leads to an endpoint energy of 4.153 ± 0.003 MeV and an intensity of 51.2 percent. The abnormally high comparative half-life ($\log ft = 7.903$) can be attributed to the difference in isotopic spin between the initial and final states. The resultant strong depression of the nuclear matrix element $< 1 >$ makes it meaningful to include in the theoretical shape factor the effect of the usually neglected matrix element $< i\,\alpha \cdot r >$. From the shape measurement and the determination of the comparative half-life, it is found that the amount of $T = 3$ admixture in the $T = 2$ ground state of Ga^{66} is 4.00×10^{-5}.

Determination of Nuclear Matrix Elements in the Non-Unique First Forbidden Beta-Decay of $Eu.^{152}$ K. S. R. SASTRY, Indiana University.—Nuclear matrix elements governing the non-unique once forbidden 1485 kev outermost β-transition in the decay $Eu^{152} \rightarrow Gd^{152}$ have been determined using our β-γ directional correlation data, the β-circularly polarized γ-ray correlation measurements of Berthier and of Alexander and Steffen and the β-spectrum shape results of Langer and Smith. Values of the individual matrix elements obtained from this analysis will be presented and their significance will be discussed.

Measurement of the Thermal Neutron Diffusion Parameters of Water by the Pulsed Neutron Method[1]

MANUEL M. BRETSCHER, Valparaiso University

Pulsed neutron techniques have been used to measure diffusion parameters of thermal neutrons in water at 26°C. Preliminary results are 212 ± 11 μsec for the mean thermal lifetime, 36,985 ± 1630 cm^2 sec^{-1} for the average diffusion coefficient, and 5021 ± 2490 cm^4 sec^{-1} for the diffusion cooling coefficient. From these results the thermal absorption cross section of hydrogen and the thermal diffusion length in water are found to be 322 ± 17 mb and 2.82 ± 0.09 cm, respectively. Moderators with geometric bucklings ranging from 0.000 cm^{-2} to 0.600 cm^{-2} were used for the lifetime measurements. Harmonic effects limit the precision of the results.

Introduction

Knowledge of the diffusion parameters of thermal neutrons in water is of fundamental importance in the design of nuclear reactors. These parameters, namely, the mean thermal lifetime, the thermal absorption cross section, the diffusion coefficient, the diffusion length, and the diffusion cooling coefficient, may all be measured by either static or dynamic methods. The pulsed neutron technique (2, 9), is capable of measuring all of these diffusion parameters in a relatively straightforward manner and with good accuracy. Basically, the experiment consists of irradiating the sample with a short burst of neutrons and measuring the time decay constant of the fundamental mode of the thermal neutron flux as a function of the size and shape of the sample, that is, the geometric buckling. The measurement of the diffusion parameters of thermal neutrons in water by the pulsed neutron technique was begun about a year ago at Valparaiso University and some of the results are presented below.

Theory of Measurement

The diffusion of thermal neutrons in a homogeneous source-free medium is described by the equation

$$D_o \nabla^2 n(\vec{r},t) - \frac{1}{T} n(\vec{r},t) = \frac{\partial}{\partial t} n(\vec{r},t) \qquad (1)$$

where

$n(\vec{r},t)$ = the number of thermal neutrons per unit volume at position $\vec{r}$ and time t

D_o = the thermal diffusion coefficient

T = the mean thermal lifetime.

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[1] Much of the instrumentation used in these measurements was purchased out of a grant from the Division of Reactor Development of the U. S. Atomic Energy Commission. This assistance is gratefully acknowledged.

This equation has the general solution

$$n(\vec{r},t) = \sum_{ijk}^{\infty} A_{ijk} F_{ijk}(\vec{r}) e^{-\alpha_{ijk} t} \tag{2}$$

where

$$\alpha_{ijk} = \frac{1}{T} + D_o B_{ijk}^2 - C B_{ijk}^4. \tag{3}$$

$F_{ijk}(\vec{r})$ and B_{ijk}^2 are, respectively, the eigenfunctions and corresponding eigenvalues of the Helmholtz wave equation

$$\nabla^2 F(\vec{r}) + B^2 F(\vec{r}) = 0$$

subject to the boundary condition that $F_{ijk}(\vec{r})$ vanish on the extrapolated boundaries of the system. Theory indicates that these extrapolated boundaries are at a distance

$$\epsilon = 2.13 D_o / \bar{v} \tag{4}$$

beyond the physical boundaries of the medium, where $\bar{v}$ is the average neutron velocity. The lowest eigenvalue is usually denoted by B^2 (without subscripts) which is called the geometric buckling. In the thermal neutron velocity distribution the faster neutrons tend to leak out of the medium more rapidly than the more slowly moving neutrons, leaving a velocity distribution characterized by a temperature somewhat below that of the medium. This effect is known as diffusion cooling and is measured in terms of the diffusion cooling coefficient C appearing in Eq. (3).

For an isotropic point source of neutrons located below but on the axis of a cylindrical moderator, the eigenfunctions and eigenvalues in Eqs. (2) and (3) have the form

$$F_{j,k}(r,z) = J_o(\alpha_j r/R) \sin(k\pi z/H)$$
$$B_{j,k}^2 = (\alpha_j/R)^2 + (k\pi/H)^2$$

where

α_j = the jth zero of the J_o Bessel function
$k = 1, 2, 3, \ldots$
$R = R_o + \epsilon$
$H = H_o + 2\epsilon.$

R_o and H_o are the physical radius and height of the cylinder, respectively, and ϵ is the extrapolation distance given by Eq. (4). The radial and axial coordinates (r,z) are measured from the base of the cylinder. Now, the neutron distribution corresponding to the fundamental mode becomes

$$n_{11}(r,z,t) = A_{11} J_o(2.405r/R) \sin(\pi z/H) e^{-\alpha t} \tag{5}$$

with

$$\alpha = \frac{1}{T} + D_0 B^2 - C B^4 \qquad (6)$$

and

$$B^2 = (2.405/R)^2 + (\pi/H)^2. \qquad (7)$$

Measurement of α, the decay constant of the fundamental mode, for a variety of cylindrical sample sizes yields data which may be fitted by the method of least squares to Eq. (6), using an iteration procedure with Eqs. (4) and (7) so that the extrapolation distance ϵ can also be found from the data. This then determines the diffusion parameters T, D_0 and C. Since $T = (v\Sigma_a)^{-1}$, where Σ_a is the macroscopic absorption cross section, the absorption cross section for "1/v" absorbers may be found from the mean thermal lifetime. The value of B^2 for which the decay constant $\alpha = 0$ is equal to minus the square of the reciprocal of the thermal diffusion length L. From Eq. (6), therefore,

$$L^2 = D_0 T[\ 1 + C(D_0{}^2 T)^{-1}]$$

when $4C << D_0{}^2\,T$.

Experimental Arrangement

The experimental arrangement for the neutron lifetime measurements is shown in Fig. 1. The pulsed neutron generator is Model 150 -1H manufactured by the Texas Nuclear Corporation. Neutrons of 14 Mev energy are produced essentially isotropically by the interaction of 150 kev deuterons on a tritium target with a possible source strength of about 4 x 10^{10} n/sec. These fast neutrons are slowed down to thermal energies as a result of successive collisions with the hydrogen and oxygen nuclei in the water moderator. Neutron pulse widths and repetition rates are continuously variable from 1 μsec to 10 msec and from 10 cps to 100 kcs, respectively.

The cylindrical moderator is located a few inches above the tritium target with its axis of symmetry passing through the target. In order to isolate the system from the large water tank which serves as a partial neutron shield, the cylinder is completely surrounded by a cadmium sheet 20 mils thick. Cadmium of this thickness is a virtually perfect absorber of thermal neutrons.

Neutrons were detected by means of a neutron-sensitive scintillation probe manufactured by the Nuclear-Chicago Corporation (Model DS8-10). The 96 percent enriched B^{10}, Zn(Ag) activated crystal had a diameter of $\frac{5}{32}$ inch, a thickness of 0.04 inch, and was mounted at the end of a lucite light pipe 42 inches long. Since lucite has very nearly the same thermal neutron properties as water, this detector introduces a negligible perturbation into the system and acts essentially as a point detector. By locating this thin crystal detector on the mid plane of the cylinder and at a radial distance equal to (2.405 R/5.520) from the axis, contributions to the count rate from the first radial and first axial harmonic modes are eliminated.

Pulses from the detector are amplified and fed into a 20-channel time analyzer manufactured by the Fairport Instrument Company. Channel

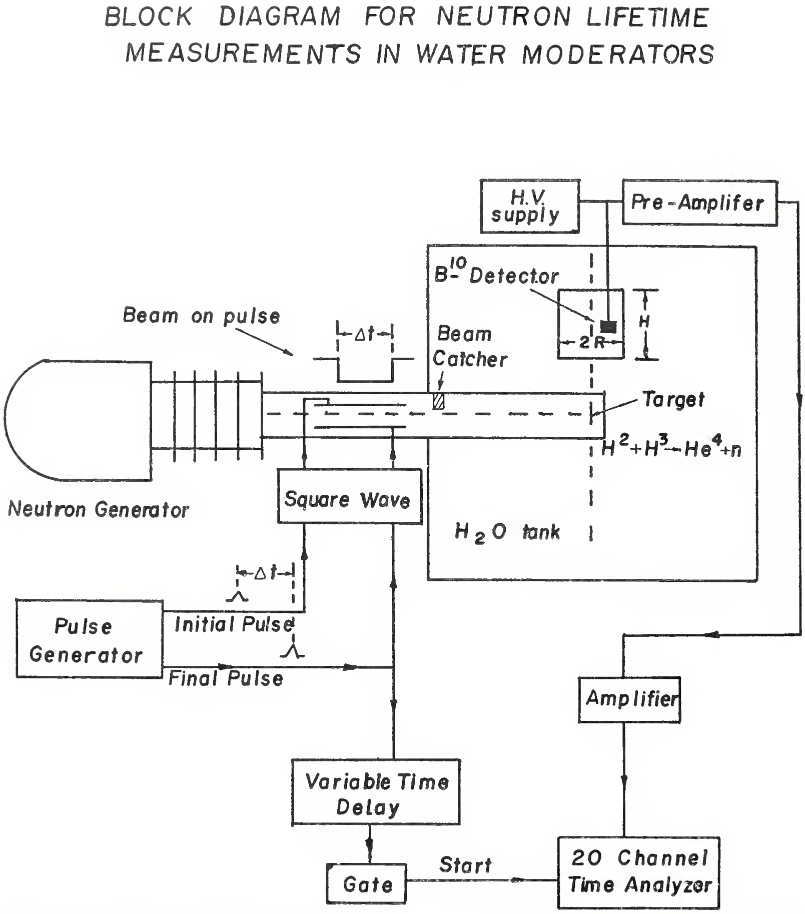
BLOCK DIAGRAM FOR NEUTRON LIFETIME MEASUREMENTS IN WATER MODERATORS
H.V. supply
Pre-Amplifer
B^{10}- Detector
Beam on pulse
Δt
Beam Catcher
H
2R
Target
$H^2+H^3 \rightarrow He^4+n$
Neutron Generator
Square Wave
H_2O tank
Δt
Pulse Generator
Initial Pulse
Final Pulse
Amplifier
Variable Time Delay
Gate
Start
20 Channel Time Analyzer

Figure 1. Experimental arrangement and instrumentation for neutron lifetime measurements.

widths from 10 to 10^5 μsec are available. Since the harmonic modes decay more rapidly than the fundamental mode, a variable time delay following the termination of the neutron pulse is inserted before triggering the time analyzer. Typical delay times ranged from 100 to 200 μsec.

Experimental Results

Deionized water having a resistivity of about 1 x 10^7 ohm—cm and a temperature of 26°C was used for all the lifetime measurements. Fig. 2 shows experimental decay curves for thermal neutrons in water for cylinders of various sizes and shapes. The actual cylinder dimensions and corresponding decay constants and geometric bucklings are listed in Table I. A plot of the decay constant versus the geometric buckling B^2 is shown in Fig. 3. The departure of the data from a straight line at large values of B^2 is a clear indication of the diffusion cooling

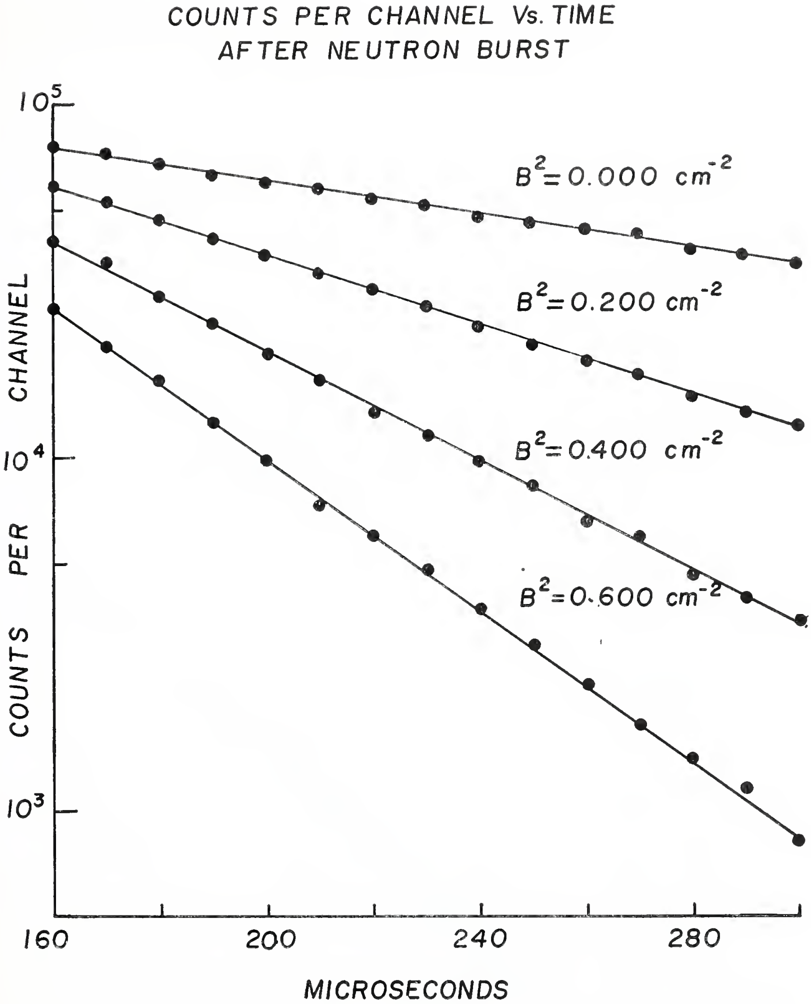

Figure 2. Semilogarithmic plot of count rate versus time after neutron burst for several different geometries.

effect. The diffusion parameters for thermal neutrons in water as obtained from this measurement are shown in Table II where other experimental results (1, 3-8) are quoted for comparison. The absorption cross section σ_a (H) is that for hydrogen since the absorption cross section for oxygen is completely negligible.

Summary

The diffusion parameters for thermal neutrons in water have been measured by the pulsed neutron method. Results are in good agreement with recently published data, although statistical errors are relatively

TABLE I. Experimental Data

($\epsilon = 0.34$ cm)

Moderator Size R_o (cm) x H_o (cm)	α (sec^{-1})	B^2 (cm^{-2})
84 x 152	$(4.767 \pm .03)10^3$	0.000
5.72 x 14.56	$(11.60 \pm .07)10^3$	0.200
5.72 x 9.64	$(13.72 \pm .13)10^3$	0.250
5.72 x 7.63	$(15.40 \pm .14)10^3$	0.300
5.72 x 6.47	$(17.43 \pm .17)10^3$	0.350
5.72 x 5.63	$(18.79 \pm .15)10^3$	0.400
3.81 x 8.58	$(19.90 \pm .13)10^3$	0.450
3.81 x 7.05	$(22.12 \pm .17)10^3$	0.500
3.81 x 6.09	$(23.42 \pm .27)10^3$	0.550
3.81 x 5.41	$(25.18 \pm .20)10^3$	0.600

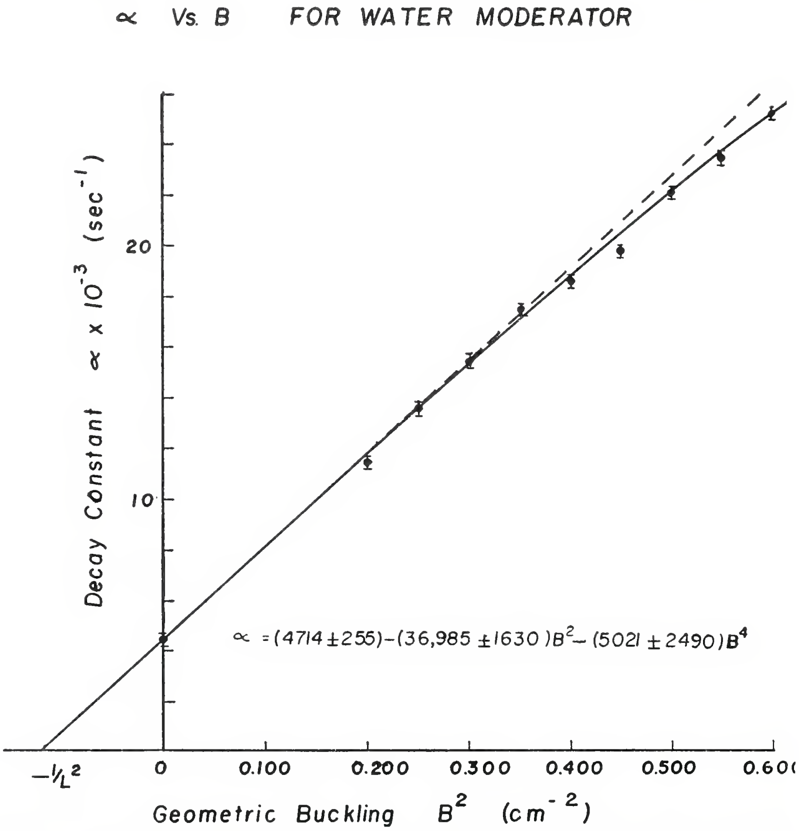

Figure 3. Least squares fit of decay constant versus geometric buckling.

large. Much of this error arises from interfering harmonic modes and work is currently in progress to reduce these harmonic contributions

TABLE II. Experimental Results

Thermal Neutron Diffusion Parameters For Water

Reference	T (μsec)	D_o (cm^2-sec^{-1})	C (cm^4-sec^{-1})	σ_a^H (mb)	L (cm)
This Work	212 ± 11	36,985 ± 1,630	5,021 ± 2,490	322 ± 17	2.82 ± .09
8	204 ± 2	36,340 ± 750	7,300 ± 1,500	333 ± 3	2.72 ± .03
1	207 ± 6	35,000 ± 1,000	4,000 ± 1,000	329 ± 10	2.7 ± .1
3	202 ± 6	34,850 ± 1,100	3,000 ± 1,000	337 ± 10	2.66 ± .11
4	208 ± 4	35,450 ± 600	3,700 ± 700	328 ± 6	2.72 ± .06
5	209 ± 6	35,400 ± 700	4,200 ± 800	326 ± 6	2.72 ± .08
7	198 ± 23	36,146 ± 5,600	5,666 ±11,670		
6	210 ± 1	36,892 ± 400	5,116 ± 776	325 ± 2	2.80 ± .02

and to increase the neutron detection efficiency as well as the neutron source strength.

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PLANT TAXONOMY

Chairman: Grady Webster, Purdue University
Joseph Hennen, Indiana State College, was elected chairman
for 1963

ABSTRACTS

Notes on the Comparative Biology of the Eastern North American Species of Bidens. Gustav W. Hall, Indiana University.—Although well-known taxonomically through the monographic study of Sherff (1937) and of others, little has been recorded of the biology of speciation of any portion of the cosmopolitan genus *Bidens* (Compositae, 270 spp.).

The three sections of the genus most conspicuous in and largely restricted to eastern North America demonstrate a progressive loss of accommodation for cross-pollination, e.g., loss of the genetic self-incompatibility barrier, reduction or absence of rays; modification of disk floret morphology and pollen presentation. Accompanying this shift in breeding system are virtual absence of known natural hybrids and a breakup of the advanced species into numerous local races. The investigation has so far centered on the two smaller sections, Meduseae with 4 diploid species, and Heterodonta with 3 or 4 tetraploid species; within each, fertile species hybrids can be readily produced by artificial crossing in the greenhouse. The members of the Meduseae, showy and wholly cross-pollinated, have apparently been maintained in nature by ecological preferences and partial allopatry, now being put to the test by widespread migration of two species. The Heterodonta line, through self-fertilization and restriction to a very narrow estuarine habitat, has evolved into a group of highly endemic, allopatric taxa scattered from the St. Lawrence to the Susquehanna River.

Preliminary Taxonomic and Chromatographic Studies of Marigolds *(Tagetes)*. Robert T. Neher, Indiana University.—The genus *Tagetes* comprises some 60 valid species ranging from Southwestern United States to Argentina. Subgenera have not previously been recognized but the recent cytogenetic studies of Dr. J. W. Towner of the University of California at Los Angeles, along with the oil and pigment analyses carried out by the author in collaboration with Dr. E. Ikenberry of LaVerne College make it clear that two natural groups are present. They may be distinguished by the morphology of the leaves (filiform or simple vs. compound), the odor (anisate vs. tagetone), and apparently a complete barrier to hybridization.

Notes on Indiana Algae, Primarily from Putnam County. Charles R. Hall, Emmerich Manual Training High School, Indianapolis, Indiana. —New county reports of algae from Putnam County, Indiana, are added to the 207 species and varieties reported to the Indiana Academy of

Science during the 1961 fall meeting. There are also several new reports for the state of Indiana from Putnam County and other areas of Indiana. All specimens have been preserved by drying on glass slides or mica sheets and are located in the Herbarium of DePauw University, Greencastle, Indiana.

Preliminary Studies on the Genus *Tragia* (Euphorbiaceae). KIM I. MILLER, Purdue University.—The pollen grains of *Tragia* fall into three general classes with the most common and widespread type being tricolporate and oblate spheroidal in shape. The exine is usually thicker in the area around the colpi and ornamented with pila on its surface. The bases of the pila are connected by a minute reticulum. A rather large operculum is present on the colpi membranes. A second class of pollen, occurring only in Section Bia, possesses no aperatures of any kind and the pila may be fused at their summits (tectate) or slightly separated. The third class represents a transition between the other two. No pores are present until the grains become fully expanded at which time the spore wall ruptures and definite germ pores appear. Of the species examined this type occurs only in *T. smallii* and *T. urens*.

Cytological studies have been carried out using aceto-carmine squashes of young leaves and root tips. *Tragia urens, T. smallii, T. urticifolia,* and *T. glanduligera* have a chromosome number of $2n=44$. *Tragia ramosa* has a number of $2n=c.\ 110$. These are the first chromosome counts reported for *Tragia* and indicate that the base number for the genus is $x=11$.

The Chromosomes and Affinities of the Genus *Reverchonia*. GRADY L. WEBSTER, Purdue University.—*Reverchonia,* a monotypic genus of Euphorbiaceae restricted to sandy desert areas in the southwestern U. S. and Mexico, is unusual in being the only genus outside Australia with extremely narrow cotyledons. Palynological studies have shown that the microspores of *Reverchonia* resemble those of some American species of *Phyllanthus* sect. *Phyllanthus*. Cytological observation of mitotic figures have demonstrated a chromosome number of $2n=16$. This number has so far been found only in *Phyllanthus* sect. *Isocladus,* the taxa of which have somewhat similar pollen grains but very different floral and vegetative features. *Reverchonia* may prove to be an aberrant, highly specialized group related to sect. *Isocladus*.

Migratory and Phylogenetic Trends in *Prenanthes*. WAYNE L. MILSTEAD, Purdue University.—Twenty-one species of *Prenanthes,* family *Compositae,* were examined to evaluate their relative positions on an advancement index scale. This was based on assigning varying values to morphological characters depending on the degree of advancement they exhibited. From this a dendrogram was constructed to show possible phylogenetic relationships of these species. Suggested migratory routes from the purported center of origin in Central Asia were also shown. The New World members of the genus appear to be the most primitive, with a trend to a more advanced nature in Southern Asia and Europe.

Studies on a New Species of *Allomyces*. JOE F. HENNEN, Indiana State College.—A new species of *Allomyces* was isolated from soil obtained near Blunt, South Dakota while working in cooperation with C. J. Mankin, South Dakota State College. Hemp seed bait was used to obtain water cultures. These were used to obtain bacteria free cultures on agar media. This species differs from all other known species primarily in that the resting sporangial walls are reticulate rather than pitted and the resting sporangia are formed basipetally within the hyphae, thus producing long rows of resting sporangia. The sexual stage has not been observed. The reticulate wall pattern of this new species seems to indicate close relationship between *Allomyces* and *Blastocladiella*.

Some Observations on Pollination and Compatibility in *Magnolia*

Charles B. Heiser, Jr.,[1] Indiana University

The hypothesis that beetles were the pollinators of the earliest angiosperms was put forward by Diels in 1916. Grant (15) presented additional evidence for the primitiveness of beetle pollination and this view has recently been supported by Leppik (19), van der Pijl (26) and Eames (1961). *Magnolia* has not been the subject of detailed studies of its pollination since the time of Delpino (11) and his observations were made in Europe where no species of the genus occur naturally. Although Indiana is hardly the logical place to study pollination in *Magnolia* since only two species occur naturally in the state and these are quite rare, several species are cultivated in Bloomington and these afforded an excellent opportunity for some observations.

Magnolia tripetala L., a native of the southeastern United States, reaches its northernmost limit in southern Pennsylvania, Ohio and Indiana (10). Four trees are grown on the Campus of Indiana University. In 1961 the first flowers opened on May 8 and the trees continued flowering until June 10. A second burst of flowering occurred on one tree from June 28 to July 8. In 1962 the plants bloomed from May 2 to May 25. The flowers of *M. tripetala* have white petals, 10 to 15 cm. in length and a rather heavy odor which is frequently described as unpleasant. The flowers on first opening are trumpet shaped and the petals gradually spread so that on the second or third day after opening the flower becomes cup-shaped and finally saucer-shaped. The flowers are strongly protogynous and the stigmas, as determined by actual pollination tests, are normally receptive for a few hours to one day after the petals open. The stigmas then become appressed (Fig. 1) to the gynoecium as the petals open and the pollen begins to shed. The stamens are tardily dehiscent and fall to the base of the flower where they remain until the petals fall. So far as could be determined from observation no nectar-like secretions are produced on either the petals or gynoecium.

In 1961, it was observed that from May 8 to May 24 the stigmas of the flower were receptive only in the bud and that upon anthesis the stigmas were already appressed to the gynoecium. During this period no flowers produced fruits. The failure of normal "timing" of the flowers during this period may have been due to the exceptionally cool weather that prevailed in Indiana during the late spring of this year.

Daily visits were made to the flowers in 1961. No insects other than a few fungus gnats were observed before May 19. Flowers marked during the period from May 8 through May 17 did not set fruit. From only a small number of flowers contained beetles and never more than May 19 on a few beetles were found on the flowers, but at a given time two were observed on a single flower. Four flowers containing beetles on May 25 were tagged and later observed to set good fruits. Honeybees *(Apis mellifera)* were observed visiting the flowers on three occasions, and the two which were captured were found to have an abundance of *Magnolia* pollen on their bodies. It seems, unlikely, however, that bees could serve as important pollinators of this species, for they were observed to visit only fully opened flowers at which time the stigmas are not receptive. One trip was made to a natural stand of *M. tripetala* in Crawford County, Indiana and beetles were collected in two of the four flowers which were accessible.

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[1] Several people have aided me in various ways in this study, and particular thanks are due Mrs. Zoe Chandik and Mr. Alvin Reeves.

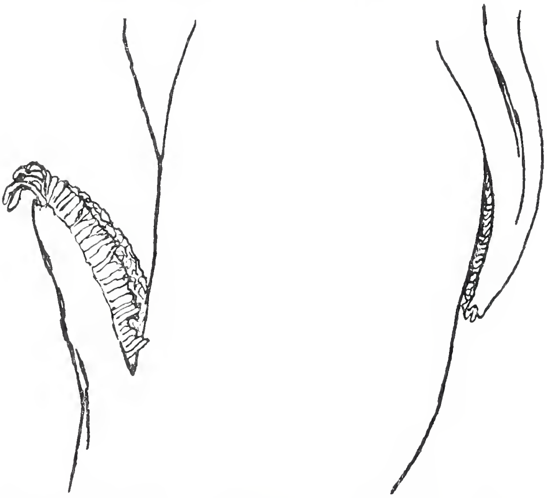

Figure 1. Stigma of *Magnolia virginica* before pollination (left) and after pollination (right) (X5.)

The following beetles were collected: Byturidae. *Byturus unicolor* Say; Coccinellidae, *Ceratomegilla maculata* De G.; Colletidae, Curulioidae, *Glyptobaris rugicollis* Lec.; Dermestidae, *Anthrenus vervasci* (L); Mylabridae, *Gibbobruchus mimus* (Say); Nitidulidae, *Carpophilus Lugibris* Morr., *Carpophilus sp., Epuraea sp.;* Staphylinidae, *Aleochara sp.* In addition to the bees, previously mentioned, a few small flies (Chloropidae, Sciaridae) were found in the flowers.[2]

Although the investigation is rather limited, it nevertheless seems reasonable to infer that *M. tripetala* is primarily, if not entirely, pollinated by beetles. Although perhaps no one beetle should be regarded as more important than the others, *Epuraea* was observed more than other species and it was found on both stigmas and stamens and was captured both at Bloomington and in Crawford County.

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[2] The preliminary identification of the insects for this study were made by Dr. David Wooldridge, and the insects were then sent to the Insect Identification Branch of the United States Department of Agriculture for verification or correction by Dr. W. H. Anderson and his staff. Their help is gratefully acknowledged. The insects are deposited in the entomological collections at Indiana University and voucher specimens of the plants in the herbarium of Indiana University.

Magnolia grandiflora L., which is native near the coast from South Carolina to Texas, has served as the chief example of beetle pollination in the Magnoliaciae. Delpino (11) reported that this species was pollinated by *Cetonia*, and this report has been widely cited, notwithstanding the fact that the study was made in Europe and that *Cetonia* is not known in North America. The flowers of *M. grandiflora* are white, quite large, cup-shaped and pleasantly odorous. The stigmas are receptive when the flower opens and drops of a nectar-like substance can be seen between the stigmas (11). After a few hours to one day the three inner petals, or rarely all the petals, close. The flower again opens on the following day, the anthers dehisce, and the readily deciduous stamens fall on the petals where they are visited by pollen gathering insects. The stigmas do not become appressed as in *M. tripetala* and it is conceivable that the stigmas could be pollinated with pollen from the same flower. Since all attempts at both self- and cross-pollination failed in this species, more specific information on this point is presently unavailable.

Insects were collected on trees cultivated in Bedford and Bloomington, Ind., Longwood Gardens, Pa., and Washington, D. C. during June and July of 1961, from flowers sent from Williamsburg, Ky. by Willard Yates, and in natural stands in Florida by Mrs. Zoe Chandik in May, 1962. Ten different beetles from six families were represented: Cantharidae, *Chauliognathus marginatus* Fab.; Dermestidae, *Anthrenus flavipes* Lec., *A. verbasci* (L.); Mordellidae, *Tomoxia sp.*; Nitidulidae, *Conotelus obscurus* Er.; Scarabeidae, *Macrodactylus subspinosus* (Fab.), *Trichiotinus bibens* (Fan.), *T. piger* (Fab.), *Popillia japonica* Newman; Staphylinideae.

Although large scarab beetles are found on this species, it again appears that the small beetles may be the more important pollinators. In Washington over 100 flowers on 15 trees were examined from June 23-25 and *Conotelus* was found in one-third of the flowers and was observed both on the gynoecium and the fallen stamens. In addition to *Conotelus*, the other beetles frequently observed on flowers in Bloomington were *Trichiotinus piger* and *Tomoxia*. The former belongs to the same family as *Cetonia* and behaves in the manner described by Delpino (11) for that species. Two specimens of *T. piger* were collected in natural stands of *M. grandiflora* in Florida and are recorded as pollinators of *Magnolia* in that state by Blatchley (5). The most frequently collected insect in Florida was an unidentified staphylinid which was not found in the collections from other areas. Honeybees, one carpenter bee, and flies (Syphidae, *Mesograpta marginata* (Say), *Metasyrphus, sp.*) were also taken. Honeybees are common visitors and it seems quite probable that they would have no difficulty in effecting pollination in this speices.

Magnolia virginiana L., another species of the southeastern United States extending as far north as Massachusetts, is cultivated in Indiana to a limited extent. The small white flower of *M. virginiana* is extremely fragrant. Its odor can be detected up to three fourths of a mile according to Peter Kalm (18). The flower buds open in the late afternoon, at which time the stigmas are receptive, and are closed by the next morning and remain closed for several hours. On the reopening the pollen is shed and the stamens fall onto the petals where the pollen is collected by insects. The stigma, although not becoming appressed to the gynoecium, is receptive only in the first stage so that this flower is protogynous.

At Bloomington from late May to mid July the following insects were collected on flowers of nine different plants: Coleoptera: Andremidae; Chrysomelidae, *Diabrotica undecimpunctata bowardii* Barber, *Metasyrphus sp.*; Coccinellidae, *Ceratomigilla Maculata* DeG; Mordellidae, *Mordellistema* sp.; Mylabridae, *Gibbrobruchus mimus* (Say); Nitidulidae; *Epuraea erichsoni* Reitter, *Gleschrochilus sp.*, *Pocadius belvolus* Er., *Stelidota geminata* (Say); Xylocopidae, *Xylocopa sp.* Diptera: Sphaeroceridae, Syrphidae, *Metasyrphus sp.;* Hemiptera: Anthocoridae; Hymenoptera: Andrenidae; Apidae, *Apis mellifera* L., *Bombus impatiens* Cr.; Lepidoptera. The two species of *Epuraea* and *Gibbrobruchus mimus* were the most frequently observed.

One of the plants studied was growing in the yard of Dr. B. A. Spencer and in the same yard 25 feet away grew a small tree of *M. grandiflora*. As can be seen from the lists of insects collected, the flowers of the two trees had almost completely different faunas.

At Longwood Gardens, Pa. individual flowers of this species were found containing as many as eight rose-chafers, *Macrodactylus subspinosus* (Fab.). Considerable damage to the petals was observed for which it may be assumed the rose-chafers were responsible. Riley (23) has previously referred to this species being found on *M. virginica.* In Georgia Mrs. Chandik collected on two plants occurring in natural stands and only staphylinids were found.

Flowers of *Magnolia macrophylla* Michx. were sent to the writer by Willard Yates, from Kentucky, which is in the natural range of this species, and they were found to contain *Trichiotinus bibens*, *Macrodoctylus subspinosus*, and *Epuraea sp.* Mrs. Chandik collected from one tree of this species in Kentucky and beetles of the families Cerambycidae, Chrysomelidae, and Curculionidae were present in the flowers.

Cross- and self-pollinations were attempted with *M. tripetala*, *M. grandiflora* and *M. virginiana* in Bloomington. Flowers which were to serve as male and female parents were covered with glacine bags prior to opening and following pollination the flowers used as the pistillate parents were rebagged for several days. All pollinations on *M. grandiflora* were unsuccessful. Self-pollination of the flower with its own pollen was found to be impossible in *M. tripetala* and *M. virginica.* Selfs were obtained, however, on three plants of these two species by using different flowers on the same plant as a source of pollen. These selfed-fruits were found to produce the same number of seeds found in open pollinated fruits of the same plants. In these two species it was found that emasculated flowers which were not pollinated failed to set fruit, and although the possibility of pseudogamous apomixis cannot yet be ruled out, it would appear that these species are self-compatible. The possibility that *M. grandiflora* is self-compatible also exists since isolated trees of this species are known to produce fruits with seeds.

Discussion

That *Magnolia* is primarily a beetle flower is substantiated by the observations on four species of *Magnolia*. Although no one beetle can be singled out as the principal pollinator, nitidulid beetles, in particular, and perhaps scarab beetles for *M. grandiflora* and *M. macrophylla*, are important pollinators. The pollen of all four species is readily accessible as is true of most beetle flowers. Visits to the gynoecium are rewarded by "nectar" in *M. grandiflora*, but no such substance appears present in *M. tripetala* and *M. virginiana*. The papillae of the stigmas bears a resemblance to the food-bodies (9) of certain beetle flowers, however, and although there is no evidence that they are eaten, they provide a possible explanation of the visits to the gynoecium. Delpino (11) suggested that *M. Yulan* was a pit-fall flowers for bees, although this was doubted by Dauman (9). It appears that the closing of the flower in *M. virginiana*, however, could serve as a temporary trap for beetles.

It has sometimes been assumed that since *Magnolia* flowers are dichomagous, cross-pollination is assured. Werth (27), for example, states that since in the first stage only the pistils are receptive, self-pollination is impossible, and that beetles, flying from flower to flower, cross-pollinate them. This is not necessarily true since beetles may fly from flower to flower on the same plant bringing about self-pollination. Dichomgamy does not necessarily lead to cross-pollination as is well known (8, 25).

Experimental evidence has been presented to show that selfing is possible in two species of Magnolia[3]. The question may be raised as to whether the first angiosperms, which are generally agreed to have been beetle flowers, were not also self-compatible. Although there is no evidence that the *Magnolias* were the first angiosperms, there is little question that they are primitive. As has been pointed out, however, by Canright (6) *Magnolia* has a number of advanced features. Obviously their compatibility could have changed since their origin. Whitehouse has written (28) that "if the original angiosperms had all possessed multiple-alleomorph incompatibility, then species which subsequently lost it would be expected to evolve more slowly and hence to show a greater range of ancestral characters than those species which retained it." This explanation could account for the primitive features of *Magnolia* and certain other angiosperms, but on the other hand the possibility that self-compatibility is a primitive feature that has been retained by certain groups deserves consideration.

Lewis (20), Stebbins (24) and Grant (15) have presented considerable evidence to show that self-compatible angiosperms are derived from self-incompatible ones, and the change is generally regarded as nearly irreversible. There can be little arguments with the examples that these authors have presented, but it does not necessarily deny the possibility that the earliest angiosperms were self-compatible. For example, Lewis and Crowe (21) state that they agree with Whitehouse that self-incompatibility has been established in the angiosperms *almost* from the time of their origin (italics mine). Fryxell, however (14), goes so far as to say, "Cross-fertilization is the 'normal' pattern of reproduction in most of the biological world, in the sense that it is the primitive, ancestral pattern."

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[3] Successful selfs were also obtained in *Michelia champaca* L., another member of the Magnoliaceae by crossing different flowers on the same plant. Carpenter and Guard (1950) however, secured only a very small number of seeds in selfs of *Liriodendron tulipifera* L., another magnoliaceous species.

It may have been advantageous for the first angiosperms, whether they were trees or herbs, to have been self-compatible, for many of the same reasons which have been postulated for the occurrance of self-fertilization as a derived condition in angiosperms today. Stebbins (24), for example, suggests that self-fertilization is an advantage where conditions are unfavorable for crossing. When the first angiosperms appeared, although they may have come from beetle pollinated ancestors, their pollination could have involved a considerable element of chance. Moreover, would seem more likely for the beetles to have moved from flower to flower on the same plant more frequently than from plant to plant. (This, of course, involves the assumption that the first angiosperms had more than one flower per plant.) Stebbins also points out that self-fertilization is an advantage for the colonization of new habitats in that it allows a few plants to rapidly build up a large colony of fit individuals, and Baker (2) has pointed out that self-compatibility is an advantage in long distance dispersal in that a single migrule can establish a colony. These advantages could have been especially important to the new angiosperms in allowing them to build up large colonies and spread widely.

Grant (16), following a discussion of the strong evidence that the change from open to restricted types of recombination systems are rare, writes, "There is also evidence for the view that recombination systems may become opened up during evolution. The earliest angiosperms were probably plants of the colonizing type. They existed as subordinate elements in Mesozoic forests until a series of climatic and biological changes opened up new habitats for which they were preadapted, whereupon they rapidly rose to dominance. These developments suggests a restricted recombination system in the early stages of angiosperm evolution." Self-pollination obviously would provide such a system of recombination.

Whitehouse (28) credits the abrupt world dominance of the angiosperms to the acquisition of multiple-alleomorphic incompatibility. Whether or not the rise to dominance was rapid (1), there can be little denying that this position was eventually achieved by securing favorable methods for outcrossing and certainly multiple-alleomorph incompatibility would provide an ideal method. Baker (3) recently has suggested that speciation would be relatively rapid after a change in the breeding system which might explain the successful adaptive radiation of the early angiosperms.

However, the change to self-incompatibility may not have occurred as one of the first steps in their evolution. The earliest flowers may have been homogamous (or synocomous, 25), such as is seen in *Paeonia* and certain members of the Ranunculaceae today (22), and self-compatible. In such types, however, some outcrossing can take place. An early development tending to promote more outcrossing may have been dichomogany. The question may be asked, however, whether or not the first angiosperms were already dichomoganous, this feature having been inherited from their progenitors. Obviously a definite answer can not be supplied, but one line of evidence suggests otherwise, for some angiosperms are protogynous and others are protandrous. Within the genus *Magnolia* where protogyny prevails, one species, *M. Delavazi* Franchet, (17) is protandrous. Dioecism also arose early in angiosperm evolution, if we can accept as evidence its occurrence in many members of the Magnoliales and Ranales. As Whitehouse (28) points out, however, dioecism is an expensive means of securing outcrossing since half of the population will not produce seed. Various types of incompatibility then later developed, perhaps independently in different lines (4). That multiple-alleomorph incompatibility comes late is suggested to me at least by the fact that some species which are dichogamous are also self-incompatible. In other words, a highly efficient method of outcrossing developed on top of a relatively inefficient method. As has been mentioned above, some self-incompatible types have since reverted to self-compatibility.

Grant (15) calls attention to the desirability of investigating the floral ecology of other primitive angiosperms. "Are the flowers of Winteraceae, *Degenaria* . . . . pollinated by beetles?" At the same time it would be interesting to learn if these primitive angiosperms are self-compatible or self-incompatible as well as to extend the observations on the Magnoliaceae.

Summary

Beetle pollination is thought to be primitive in angiosperms. *Magnolia* is generally considered a "beetle flower" but no detailed studies have been made on the genus since the time of Delpino (11) whose observations were made in Europe where no species occur naturally. Observations made on *M. grandiflora*, *M. macrophylla*, *M. tripetala* and *M. virginica* indicate that beetles are the most common visitors to the flowers. Successful selfs on *M. tripetala* and *M. virginiana* were secured by crossing different flowers on the same plant. It is pointed out that self-compatibility may have been the original condition in the angiosperms and possible advantages of a system of self-pollination, which does not exclude outcrossing, are presented.

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Records of South Texas Rust Fungi[1]

GEORGE B. CUMMINS, Purdue University

This paper reports 18 species collected during March and April 1962 in the area south of a line from Del Rio to Corpus Christi. Two of the species are new to the United States, five are new to Texas, many of the parasitized plants are new hosts for the fungi involved, and life cycles are suggested for three species. All specimens are in the Arthur Herbarium of Purdue University and duplicates are deposited in the National Fungus Collections, Plant Industry Station, Beltsville, Maryland.

PHYSOPELLA CAMELIAE (Mayor) Cummn. & Ramachar.

On *Panicum anceps* Michx., at the reservoir, Farm Road 88 north of Elsa, 26 Mar. (*62-176*); levee near Missouri-Pacific Station, Brownsville, 21 Apr. (*62-259*). On *Panicum firmulum* Hitchc. & Chase, US 77, 4 miles north of Raymondville, 20 Apr. (*62-252*).

These are the first records of this fungus parasitizing species of *Panicum*. It has been previously recorded on *Setaria macrostachya* H. B. K. and *S. scheelei* (Steud.) Hitchc. in Texas and is common in the lower Rio Grande Valley.

PUCCINIA ARISTIDAE Tracy.

On *Tridens elongatus* (Buckl.) Nash, US 90, eight miles east of Del Rio, 1 May (*62-301*).

This is a new host for the species.

PUCCINIA CACABATA Arth. & Holw.

On *Chloris ciliata* Swartz, Farm Road 1792, 16 miles east of Brownsville, 19 Mar. (*62-147*); Tex. 4, 18 miles east of Brownsville, 22 Mar. (*62-158*); Farm Road 1419, 8 miles southeast of Brownsville, 23 Mar. (*62-168*); Bentsen State Park near Mission, 28 Mar. (*62-181*).

The fungus has not been reported for the U.S. on *C. ciliata*, the host of the type. In the U.S. it is commoner on species of *Bouteloua*.

PUCCINIA CANALICULATA (Schw.) Lagh.

On *Cyperus esculentus* L., US 77, 26 miles south of Riviera, 6 Apr. (*62-205*). On *Senecio ampullaceus* Hook., same site (*62-206*).

The two plants were intergrown and the fresh uredia and telia on the *Cyperus* unquestionably resulted from aeciospores from the old aecia on the *Senecio*. A similar aecial stage occurred along US 77 five miles north of Raymondville on *Rudbeckia serotina* Nutt. (*62-254*) and on *Helianthus* (*annuus* L.?) seedlings (*62-256*); and 13 miles north on *R. serotina* (*62-256*) associated with old telia on *Cyperus* sp. Aecia have been reported previously on *Ambrosia, Heliopsis,* and *Xanthium.*

PUCCINIA CHLORIDIS Speg.

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[1] Journal Paper No. 1991 of the Purdue University Agricultural Experiment Station, Lafayette, Indiana. The author acknowledges a National Science Foundation grant (G-16418) which made the field work possible.

On *Trichloris pluriflora* Fourn., US 281, 4 miles north of Linn, 4 Apr. (*62-190*); Tex. 359, 5 miles north of Alice, 5 Apr. (*62-195*); County Park, Loyola Beach, 6 Apr. (*62-202*).

This fungus has not been reported previously in the U.S. on species of *Trichloris* but it was also found in October 1961 in the Big Bend.

PUCCINIA CIRCUMDATA Mains.

On *Panicum fasciculatum* Swartz.?, Bentsen State Park near Mission, 28 Mar. (*62-180*).

New collections will be necessary to verify the host but the grass is an annual and the remnants of the inflorescence indicate *P. fasciculatum*. The fungus was known previously from Cuba, southern Mexico, Panama, and Puerto Rico.

PUCCINIA DIETELII Sacc. & Syd.

On *Chloris andropogonoides* Fourn., Farm Road 1792, 16 miles east of Brownsville, 19 Apr. (*62-250*).

This is a new host for *P. dietelii.*

PUCCINIA ELEOCHARIDIS Arth.

On *Eupatorium serotinum* Michx., Devils River at US 90 bridge, northwest of Del Rio, 26 Apr. (*62-272*).

Aecia have not been recorded previously from Texas.

PUCCINIA HETEROSPORA Berk. & Curt.

On *Sida filicaulis* Torrey & Gray, near US 281, 9 miles north of Linn, 4 Apr. (*62-192*).

PUCCINIA IRREQUISITA Jacks.

On *Centaurea americana* Nutt. Along US 277, 10 miles east of Del Rio, 27 Apr. (*62-281*). Previously known from two collections made in 1901.

PUCCINIA MIRIFICA Diet. & Holw.

On *Borrichia frutescens* (L.) DC. Farm Road 1792, 22 miles east of Brownsville, 20 Mar. (*62-155*).

This species supposedly lacked uredia but they occur as localized infections in this material. The spores are like the uredinoid aeciospores produced on the systemic infections.

PUCCINIA PHYLLOSTACHYDIS Kus.

On *Phyllostachys* (*aurea* Riv.?), Brackenridge Park, San Antonio, 24 Apr. (*62-261*).

In the U.S. the species was previously known from Florida, Georgia, and South Carolina.

PUCCINIA POSADENSIS Sacc. & Trott.

On *Andropogon* sp., Dunes near Coast Guard Station, south end of Padre Island, 18 Apr. (*62-245*).

The only other U.S. records are from Florida and South Carolina.

PUCCINIA SUBSTRIATA Ell. & Barth.

On *Paspalum pubiflorum* Rupr., Devils River at US 90 bridge northwest of Del Rio, Apr. 26 (*62-276*); stream about 12 miles south of Del Rio on US 277, 27 Apr. (*62-282*).

This is a new host for the species.

PUCCINIA TUMIDIPES Pk.

On *Lycium carolinianum* Walt., Farm Road 1792, 16 miles east of Brownsville, 19 Apr. (*62-248*); Brownsville, 6 June 1945 (D. J. Smith).

This plant has not been recorded as a host in the U.S.

PUCCINIA VERSICOLOR Diet. & Holw.

On *Heteropogon contortus* (L.) Beauv., roadside park off of US 90 at the Pecos River, west of Comstock, 28 Apr. (*62-287*).

The species was collected in the Big Bend in October 1961 but is not known to occur elsewhere in the U.S.

UROMYCES AMERICANUS Speg.

On *Hydrocotyle umbellata* L., Devils River at US 90, 26, 30 Apr. (*62-271*; *62-297*). On *Scirpus americanus* Pers., same site, 26 Apr. 1962 (*62-274*).

The intimate association of the aecia on *Hydrocotyle* and telia with germinated spores on *Scirpus* was convincing evidence that they are related. Jackson (notes in the Arthur Herbarium) observed a similar association in 1907 in Delaware but the rust was then confused with *U. lineolatus* (Desm.) Schroet. (*U. scirpi* Burr.) In California, Parks noted (on label of No. 173, California Fungi distributed by the Herbarium of the University of California) a similar association between the telial stage on *Scirpus californicus* (Mey.) Britt. and aecia on *Oenanthe californica* S. Wats. The aecia on *Hydrocotyle* from Texas were compared with *Aecidium hydrocotylinum* Speg. by Dr. Lindquist, Institute de Botanico "Spegazzini," and considered to be conspecific. He further stated (*in litt.*) that, in unpublished work, he had established the connection between the two stages.

UROMYCES GRAMINICOLA Burr.

On *Panicum virgatum* L., sandhill area along US 77 about 16 miles south of Riviera, 6 Apr. (*62-204*).

This common species appears to be a new record for Texas.

Studies in Indiana Bryophytes XIII

WINONA H. WELCH, DePauw University

Eight additional species and varieties of mosses have been found to occur in Indiana since the publication of Studies in Indiana Bryophytes XII, Proc. Ind. Acad. Sci. **69**: 123-127. 1960, and Mosses of Indiana, in 1957.

With the two mentioned exceptions, specimens of the collections cited occur in the Herbarium of DePauw University.

The total number of known species of mosses in Indiana is presently 227, varieties 37, and forms 9, representing 97 genera and 27 families.

The author is indebted to the Graduate Council of DePauw University for a grant in aid of research.

Fissidentaceae

Fissidens obtusifolius Wils. var. *apiculatus* Grout (Fig. 1). Plants small, up to 1 cm. high, pale green or glaucous-green, leaves distichous, 4-12 pairs, oblong-lingulate to oblong, the upper about 1.4 x 0.35 mm., costa often percurrent into the apiculus, apices narrowly obtuse, usually apiculate, margins entire, occasionally flexuose, on margin of vaginant lamina of upper leaves a faint border of a few inconspicuous elongated cells occasionally present; cells of leaves generally smooth, irregularly rounded-hexagonal, hexagonal, rectangular, quadrate, median cells 6.8-10.2μ wide, 8.5-11.9μ long, 1-1.4:1.

Habitat: On moist St. Louis limestone.

Indiana distribution: Putnam County, Vermillion Falls, 6 mis. northwest of Greencastle. Aug. 23, 1958. Welch **17915**, as *F. ravenelii* Sull.; determined Aug. 4, 1960 by Howard Crum as *F. obtusifolius* var. *apiculatus.*

Encalyptaceae. Extinguisher Mosses

Plants 0.5-5 cm. high, in tufts; stems 3-5-angled; leaves crisped or not greatly changed when dry, spreading when moist, lingulate to spatulate, more or less concave, often cucullate, upper ½ or ⅔ opaque, densely papillose, apices broadly rounded to subacuminate, obtuse, acute, mucronate, or hair pointed, costa slightly to not at all excurrent, margins plane or revolute, entire or erose dentate by projecting papillae; upper median cells more or less isodiametric, quadrate, hexagonal, or irregular, slightly thickened, 8-30μ in diameter, lower cells rectangular to rhombic, basal cells larger, oblong, up to 90μ long, the longitudinal walls usually thin, end walls usually reddish, often thickened, smooth or with projecting end walls, occasionally basal cells strongly papillose, basal marginal cells linear, with thick walls; brood bodies present in many plants, in axils or on bases of leaves, reddish brown, usually oblong to filamentous, multiseptate; calyptra large, candle-extinguisher-like, covering capsule or nearly so, cylindric, long beaked, erose, lanceolate, or fringed at base;

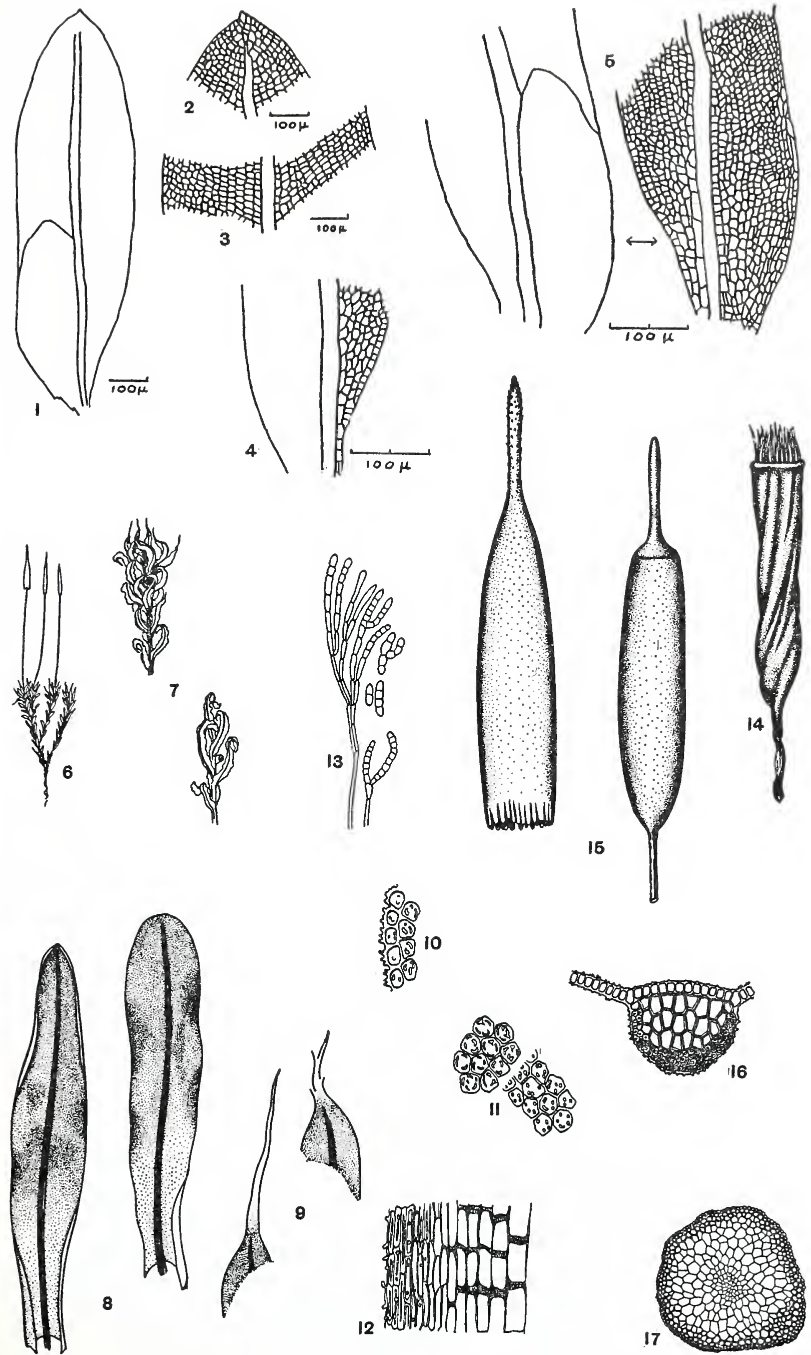

Figure 1

Figure 1. *Fissidens obtusifolius* var. *apiculatus* (drawn from Welch no. 17915). 1. Cauline leaf. 2-5. Apical, median, and basal leaf-cells, respectively. *Encalypta procera* (from Grout, MFNA **1:** *pl. 72*; all enlarged except habit). 6. Habit sketch. 7. Portion of plants, dry habit. 8. Leaves. 9. Leaf apices. 10. Upper marginal cells. 11. Upper median cells, with two types of papillae. 12. Basal cells, marginal and median. 13. Brood bodies. 14. Dry capsule. 15. Moist capsule and calyptra. 16. Cross section of costa. 17. Cross section of stem.

seta short, erect, 0.5-3 cm. long; capsules erect, cylindric, 2.5-5 mm. long, neck short, mouth bordered by 2 to many rows of colored, shorter, and thick-walled cells; annulus present; operculum long-beaked from a conical base; peristome none to 16 well-developed teeth; spores large.

Encalypta Schreb.

The only genus has the characteristics of the family.

Encalypta procera Bruch (Fig. 1). Plants in dense tufts, 1-5 cm. high; stems branched, reddish radiculose below, triangular in cross section; central strand distinct in most plants; leaves suberect to erect-spreading to recurved, subcrispate when dry or only slightly changed, ovate-oblong to spatulate, concave to almost flat, 4-5 mm. long, often clasping at base, costa stout, red with age, papillose throughout or partially smooth, percurrent or ending below apex; apices plane or cucullate, broadly rounded and obtuse or mucronate to long piliferous, hair usually hyaline, smooth or dentate; upper median cells of leaves quadrate, hexagonal, or irregular, often in rows, 14-20μ in diameter, papillae coarse, simple, forked, or lunate, marginal cells with projecting papillae, basal cells oblong, 16-22μ wide, 40-72μ long, hyaline, walls usually red, transverse walls heavily thickened, marginal basal cells linear, thick-walled, smooth or papillose, an area of basal cells extending obliquely up the margin, frequently forming a distinct contrast with green cells above; brood bodies frequently abundant, especially in sterile plants, arising as rhizoid-like outgrowths which branch dichotomously forming dense red clusters, the tips ultimately forming the 2- to 8-celled brood bodies; calyptra large, covering capsule, cylindric, beaked, 6-10 mm. long, base pale, fringed; seta 1.2 cm. long, red at base and at base of urn; capsules cylindric, red at mouth and base, 3.3-6 mm. long, often spirally furrowed when dry, mouth bordered by 2-3 rows of smaller quadrate, red cells, neck short; operculum long rostrate, often 2 mm. long, commonly falling with calyptra; annulus large, double; peristome teeth 16, red, papillose, narrowly lanceolate or linear, 1.2 mm. long, segments and cilia about the same length as the teeth or shorter; spores smooth to granular, 16-18μ in diameter.

Habitat: On wet or damp soil and in rock crevices.

Indiana distribution: Porter and Lake County line, on ground, Lake Michigan sand dune. April 4, 1948. Herbert Habeeb **1521.**[1]

Pottiaceae

Tortula papillosa Wils. (Fig. 2). Plants dark green, greenish brown or brownish when dry, usually in small dense tufts; stems short, commonly up to 5 mm., occasionally up to 10 mm. high; leaves incurved at apex and imbricated when dry, widely spreading when moist, broadly obovate or oblong to spatulate, up to 2 mm. long and 1 mm. wide, very concave, costa very conspicuous, thick, strongly spinose- to stellate-papillose on lower surface, bearing propagula or gemmae on upper

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[1] Howard Crum discovered this Indiana record in the Herbarium of the New York Botanical Garden and reported it to the author. The writer examined the collection in the Cryptogamic Herbarium of the Chicago Natural History Museum.

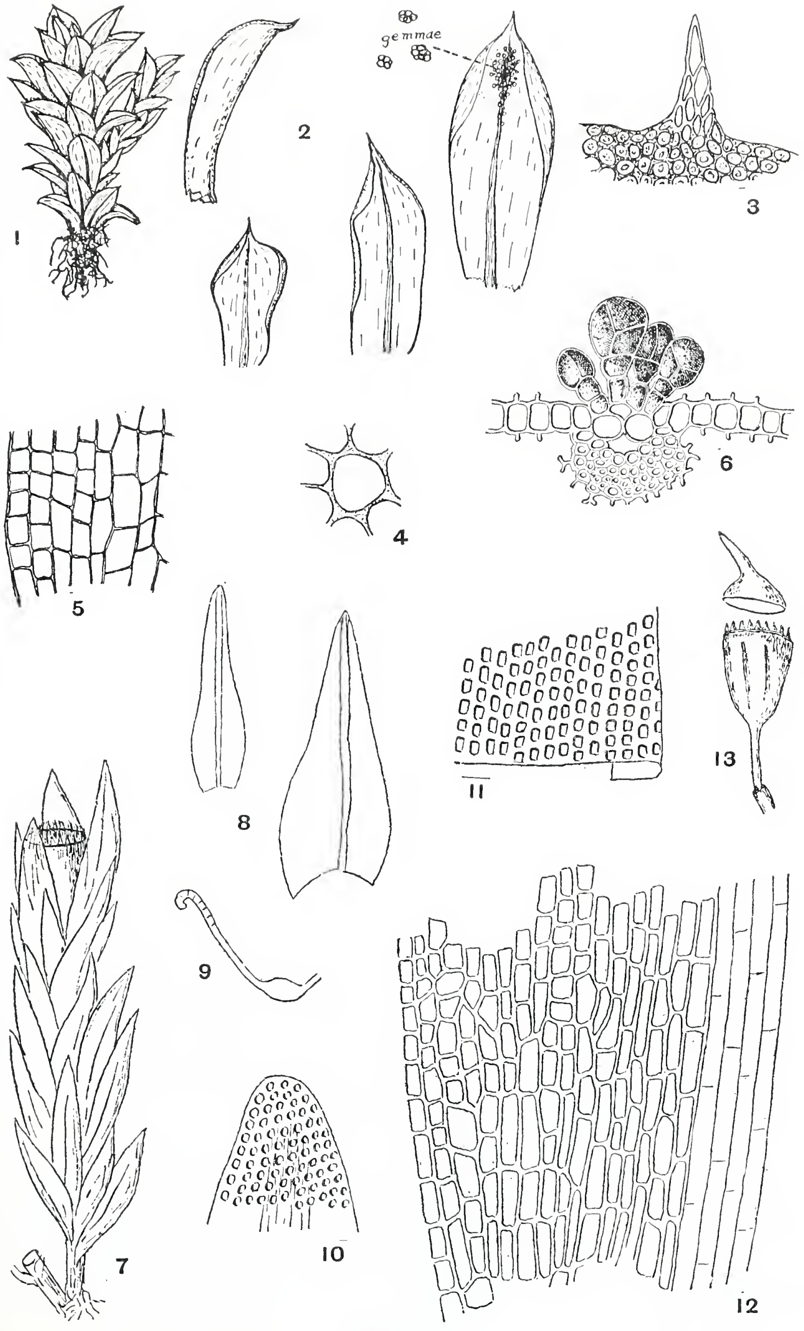

Figure 2

Figure 2. *Tortula papillosa* [1-5, enlarged, from Jennings, Man. Moss., *pl. 62*; 6, enlarged, from Grout, MHM, *fig. 79b* (after Limpricht)]. 1. Plant. 2. Cauline leaves. 3. Leaf apex. 4. Median cell. 5. Lower marginal cells. 6. Cross section of leaf through costa, showing papillae and brood bodies. *Grimmia apocarpa* var. *dupretii* (from Grout, MFNA **2:** *pl. 10* and from Thériot, Bryol. **10:** *pl. 8,* as *G. dupretii;* enlarged). 7. Plant. 8. Leaves. 9. Cross section of leaf, margin revolute. 10-12. Apical, median, and basal leaf-cells, respectively. 13. Urn and operculum, dry.

surface in upper part, especially in young leaves, excurrent into a mucro or short smooth hyaline awn, in cross section showing 2 median guide cells, approximately 4 large ventral cells, and a dorsal group of stereids; apices truncate, rounded, or retuse, obtuse or subacute; margins involute above when dry, plane or involute when moist, entire; upper leaf cells pellucid, rounded quadrate to polygonal, 20-25μ in diameter, more or less collenchymatous, smooth or nearly so on upper surface, papillose or spinose-papillose on lower surface, basal leaf cells rectangular, hyaline toward costa; propagula or gemmae suboval to oval, multicellular, composed of 2-5 clustered roundish green cells, bright or yellowish green, short pedicellate, very numerous on younger leaves, 50-80μ in diameter. According to W. C. Steere in Grout, MFNA 1: 239, 1939, the sporophyte is unknown in the northern hemisphere. H. N. Dixon, in The Students' Handbook of British Mosses, p. 205, 1924, states that the fruit has been found in Australia, only. G. O. K. Sainsbury, in A Handbook of the New Zealand Mosses, p. 184, 1955, states that the fruit is known only from Australia. On p. 184, Sainsbury includes with his description of *T. papillosa* the characteristics and measurements of the sporophytes of plants from Castlemaine, Victoria, Australia. Sainsbury, referring to Correns, Vermehrung der Laubmoose, adds the statement that the gemmae are produced not only from the nerve but also from some of the cells of the lamina.

Habitat: On trunks of living tree (elms, ash, willow), rarely on rock.

Indiana distribution: Randolph County, on bark of ash tree in the lawn of Robert Holliday, 6 miles north of Modoc or 3 miles south of Farmland, on Highway 1. June 16, 1962. Winona H. Welch **20221, 20222.** Collections are deposited in the Herbarium of DePauw University.

Grimmiaceae

Grimmia apocarpa Hedw. var. *dupretii* (Thér.) Sayre[2] (Fig. 2). Plants short, dark green, in dense tufts; stems up to 5 mm. long; leaves ovate-lanceolate or lanceolate, carinate, 1-1.3 mm. long, costa strong, narrow at base, wider above, percurrent, apices of upper leaves short-acuminate or acute, muticous throughout, margins revolute, entire, upper cells of leaves rounded quadrate, 6-8μ in diameter, walls hyaline; calyptra mitrate; seta 0.6 mm. long; capsule immersed, ellipsoid; spores smooth, 12-15μ in diameter, mature in summer.

Habitat: On various rocks.

Indiana distribution: Putnam County, Vermillion Falls, near Greencastle. Aug. 23, 1958. H. A. Miller **5598, 5604**; Hoosier Highlands. Aug. 24, 1958. H. A. Miller **5648.** Each of these collections is a mixture of *Grimmia apocarpa* var. *alpicola* and var. *dupretii*, as determined by Geneva Sayre, Aug. 20, 1960. Miller's collections are at Miami University.

Funariaceae

Pyramidula tetragona (Brid.) Brid. (Fig. 3). Plants small, cespitose; stems about 1 mm. high; upper leaves 1-1.5 mm. long, suberect,

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[2] Indiana distribution: Not known.

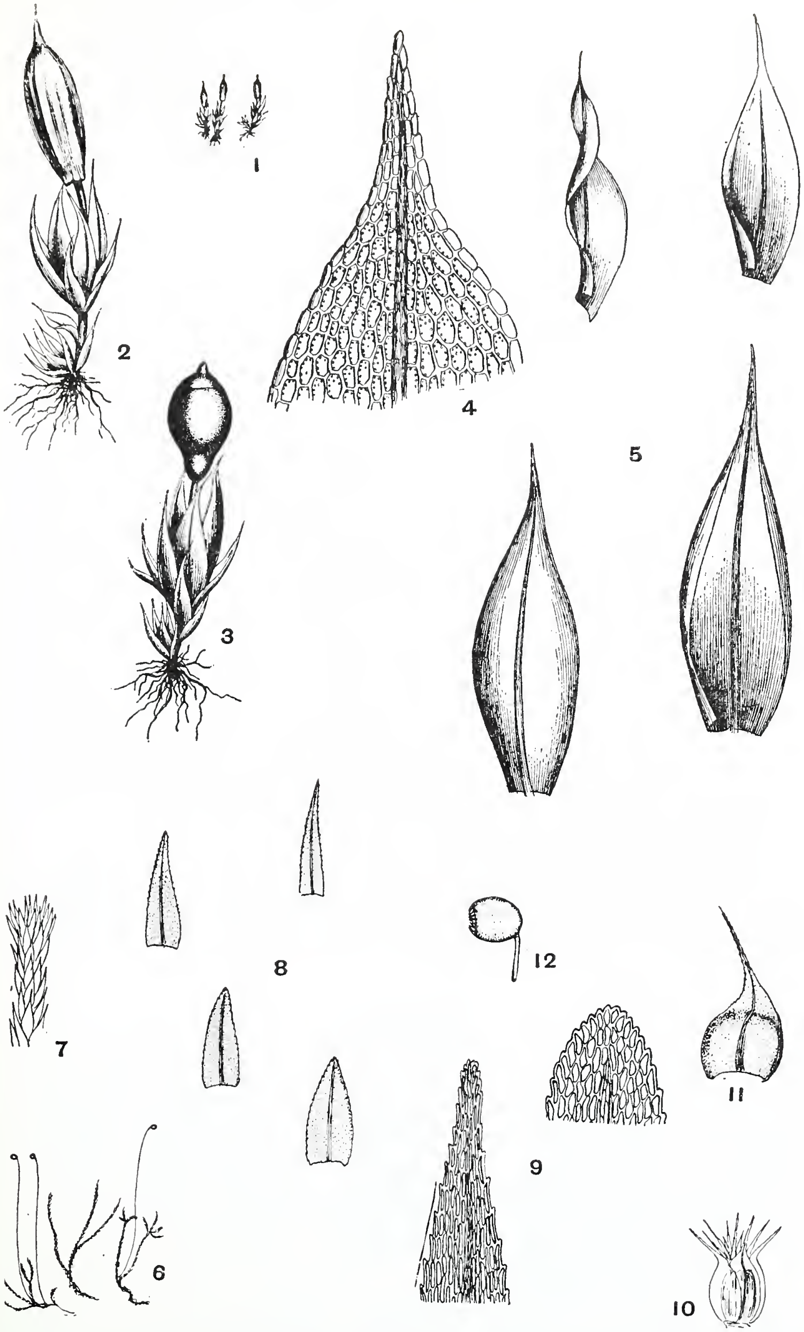

Figure 3

Figure 3. *Pyramidula tetragona* (from Grout, MFNA **2**: *pl. 28;* from Bry. Eur., *pl. 298*; all enlarged except 1 & 6, natural size). 1. Plants, with fruit. 2. Plant, showing 4-angled calyptra. 3. Gametophyte, bearing sporophyte. 4. Apical cells. 5. Leaves. *Philonotis gracillima* (from Grout, MFNA **2**: *pl. 67A*; enlarged). 6. Plants, with fruit. 7. Porton of foliated stem. 8. Leaves. 9. Apices of leaves. 10. Perigonium. 11. Perigonial leaf. 12. Urn, with peristome.

contorted when dry, ovate to oblong-ovate, rather abruptly long-acuminate, concave, costa ending in upper leaf or extending to near the tip of the slender acuminate apex, margins plane, entire; cells of leaves large, the lower about 18μ wide, 36-72μ long, the upper rhombic-hexagonal; calyptra large, 4-angled, split on one side, entirely covering the capsule; seta 1-2 mm. long; capsule erect, emergent or barely exserted, globose pyriform, about length of seta, mouth bordered by about 6 rows of transversely elongated cells; operculum small, mammillate-apiculate; peristome lacking; spores smooth, 45-70μ in diameter, maturing in early spring.

Habitat: On soil and on layer of soil on rock.

Bartramiaceae

Philonotis gracillima Ångstr. (Fig. 3.) Plants small, 1-1.5 cm. high, bright green, tomentose near base; stems not hooked at tips; branches irregularly arranged or in whorls; leaves erect-spreading to spreading, subtriangular, ovate-oblong, or oblong-lanceolate, 0.4-1 mm. long, apices obtuse, margins plane or slightly recurved, dentate, teeth blunt, costa ending below apex; upper cells linear-oblong or rhomboidal, faintly papillose on lower surface, papillae at upper end of cells, basal cells lax and subhyaline or hyaline; dioicous; perigonia gemmiform, often appearing lateral, subtended by 1-5 branches, bracts transparent, 1-1.2 mm. long, sheathing at broad base and abruptly slenderly acuminate at apex, costa narrow, very faint, antheridia and brownish paraphyses visible through bracts; seta 2 cm. long; capsule reddish brown, horizontal or nearly so, ovoid, furrowed upon drying, 1-1.5 mm. long, mouth small, suboblique; peristome complete, teeth lanceolate, acuminate, knobbed at tip; spores reniform, densely papillose, 20-26μ in diameter.

Habitat: On sandstone bluff.

Indiana distribution: Warren County, Little Pine Creek Gorge, near Bridge, about 13 miles southwest of Lafayette. Aug. 27, 1961. Robert R. Ireland, Jr. 5401. Collection deposited in The United States National Herbarium.

Hypnaceae

Isopterygium elegans (Hook.) Lindb. [*Plagiothecium elegans* (Hook.) Sull.] (Fig. 4.) Plants bright green to dark green, small, glossy, prostrate, in mats; stems 2-3 cm. long, irregularly branching, cortical cells small, thick-walled; branches up to 1 cm. long, sometimes flagellate at ends; foliated stems and branches complanate, appearing distichous; leaves commonly symmetric, oblong-ovate, oblong-lanceolate, or ovate-lanceolate, 1-1.5 mm. long, about 0.35 mm. wide, subconcave, narrowed from about midleaf into slender acumination, base rounded,

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3. Through an oversight, the author missed Grout's reference to the occurrence of this species in Indiana, Moss Flora of North America North of Mexico **2**: 73, 1935, during the preparation of Mosses of Indiana (1957). The writer's attention was called to this omission by Arthur Cridland. Attempts to locate Indiana specimens of this moss in the herbaria of The New York Botanical Garden, Chicago Natural History Museum, Duke University, Missouri Botanical Garden, and DePauw University have been unsuccessful.

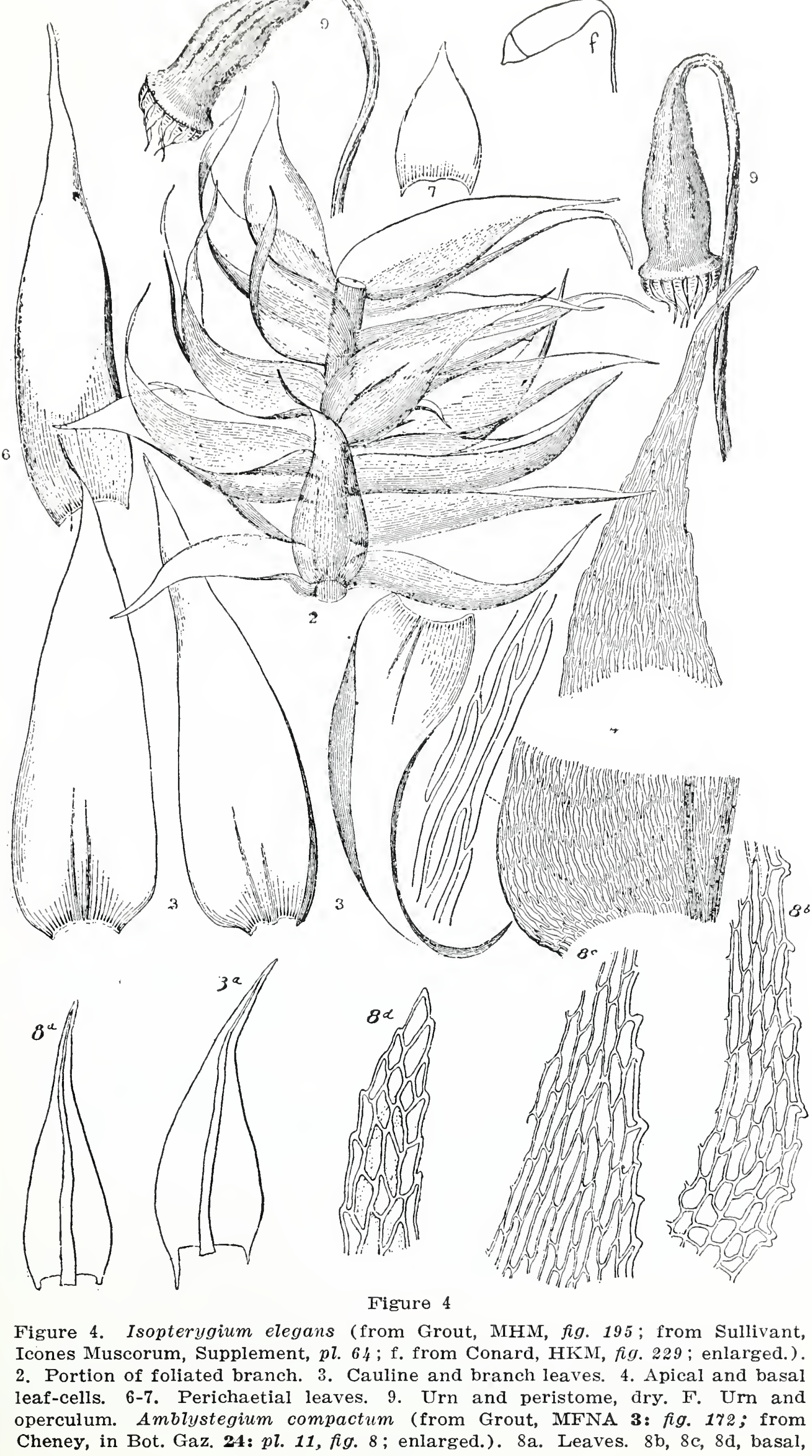

Figure 4

Figure 4. *Isopterygium elegans* (from Grout, MHM, *fig. 195*; from Sullivant, Icones Muscorum, Supplement, *pl. 64*; f. from Conard, HKM, *fig. 229*; enlarged.). 2. Portion of foliated branch. 3. Cauline and branch leaves. 4. Apical and basal leaf-cells. 6-7. Perichaetial leaves. 9. Urn and peristome, dry. F. Urn and operculum. *Amblystegium compactum* (from Grout, MFNA **3:** *fig. 172;* from Cheney, in Bot. Gaz. **24:** *pl. 11, fig.* 8; enlarged.). 8a. Leaves. 8b, 8c, 8d, basal, median, and apical cells, respectively.

rather narrow, non-decurrent, costa double, with one fork longer, sometimes extending ⅓ length of leaf, apices frequently extending downwards, margins of blades plane, entire except in the more or less serrulate acumination; in axils of leaves of stems and branches frequent gemmiform branchlets with minute leaves; median cells of normal leaves linear-flexuose, 4-7 x 70-100μ, 20-30:1, alar cells scarcely differentiated from the shorter basal rows; dioicous; seta 12-20 mm. long; capsules inclined to pendent, nearly symmetric, ovoid to oblong-ovoid; urn about 1.5 mm. long; operculum conic-apiculate, obtuse; annulus of large deciduous cells; peristome perfect; spores mature in early spring.

Habitat: In moist shaded crevices of sandstone (non-calcareous rock) and on humus in similar situations.

Indiana distribution: Warren County, Little Pine Creek Gorge near High Bridge, about 13 miles southwest of Lafayette. Aug. 27, 1961. Robert R. Ireland, Jr., 5399. Collection is deposited in The United States National Herbarium.

Amblystegium compactum (C. Müll.) Aust. [Originally, *Hypnum compactum* C. Müll.; in Index Muscorum (1959), *Rhynchostegiella compacta* (C. Müll.) Loesk.] (Fig. 4.) Plants very small, usually in deep tufts, up to 2.5 cm. deep, pale green, yellowish within dense tufts, brittle when dry; stems irregularly branching, radiculose, some radicles minutely scabrous; leaves erect to erect-spreading, often slightly secund, ovate-lanceolate, gradually narrowed to slender acumination, narrowly decurrent, the cauline 0.75-1 mm. long, margins plane, usually finely and sharply denticulate throughout, basal teeth often recurved, frequently double by projecting outer walls of two adjacent cells at their common wall, costa 30-37.5μ wide at base, gradually narrowing into apex, subpercurrent to percurrent, frequently with radicle-like structures or delicate jointed brood-filaments from lower surface or from apex; branch leaves smaller, lanceolate; median leaf cells linear-rhomboidal, 40-60μ long, 4-10:1, alar cells not inflated; usually autoicous; calyptra short, covering operculum; seta 1-3 cm. long; capsule suberect to erect, clavate-oblong, symmetric or nearly so, 1.5-3 mm. long; operculum conic-apiculate; annulus present; peristome complete or incomplete, with cilia short or lacking; spores apparently mature in spring.

Habitat: On moist or wet decayed wood, bases of trees, and rock, especially calcareous stone.

Indiana distribution: Warren County, Little Pine Creek Gorge, near waterfall, at High Bridge, about 13 miles southwest of Lafayette. Aug. 27, 1961. Howard Crum 11658. The collection is in the Herbarium of the National Museum of Canada.

Notes on Some Algae Found in Indiana

William A. Daily, Butler University

The specimens cited here are to be found in the writer's personal herbarium on file in the Ray C. Friesner Memorial Herbarium of Butler University.

Unless otherwise noted, the species and one variety listed here are new reports for Indiana and were collected by Mrs. Fay K. Daily and the writer.

A check-list of algae reported collected in Indiana is kept on file in the Botany Departemnt of Butler University.

I wish to acknowledge the aid and suggestions given by Drs. Ruth Patrick, Charles Reimer, Francis Drouet and Mrs. Fay K. Daily.

Bacillariophyceae

Achnanthes clevei Grun., *Amphora veneta* (Kütz.) Hus., *Cymbella mexicana* (Ehr.) R.S., *C. sinuata* Grey, *Fragilaria nitzschioides* Grun., *Melosira roseana* Rabh. and *Navicula gracilis* Ehr.

Warren County: With filamentous Chlorophyceae on sand beneath sandstone overhang. Kickapoo Falls near Attica, no. 3031, Aug. 31, 1961.

Chlorophyceae

Schizochlamys aurantia (Ag.) Dr. & Da.

Steuben County: In shallow water, on bottom of Gentian Lake, Wing Haven, 6 mi. N. of Angola, no. 2673, Aug. 24, 1953.

Tetrallantos Lagerheimii Teil.

Parke County: With *Gomphosphaeria Wichurae* (Hilse) Dr. & Da. Tow from bank of Thomas Lake, 1½ mi. east of Lena, no. 2531, Aug. 25, 1951.

The genus was first reported for Indiana by Palmer and Brown (4) in 1959, but a description was not given of, quote, "a colonial green alga belonging to the genus *Tetrallantos*." This genus is monotypic and the specimen we collected in a small artificial lake fits the description of *T. Lagerheimii*. It is a rare soft-water plankter.

Volvox Carteri Stein.

Marion County: A bloom in pond at Riverside Fish Hatchery, Indianapolis, no. 2752, July 24, 1955.

This specimen was identified by the late Dr. G. M. Smith on Aug. 9, 1955. According to him, it was known definitely only from India and the vicinity of Manila, Philippine Islands previous to this Indiana collection. Zygotes of *V. Carteri* differ from zygotes of all other species in that the mature wall is crenulate in outline.

Zoochlorella parasitica Brandt.

Elkhart County: Floating in Little Lake Simonton, 5 mi. north of Elkhart, no. 2624, Aug. 26, 1952; Kosciusko County: In shallow water near Johnson's Hotel, Lake Wawasee, no 2694, Aug. 27, 1953; Marshall

County: A very pale blue-green gelatinous ball on bottom of Lake Maxinkuckee near outlet, Culver, no. 1541, Aug. 5, 1946.

This alga frequently passes under the name of *Chlorella* and generally is found inhabiting *Ophrydium* species.

Euglenophyceae

Trachelomonas volvocina var. *punctata* Skvortzow.

Marion County: On surface of pond at Riverside Fish Hatchery, Indianapolis, no. 1569, Aug. 18, 1946.

Myxophyceae

Anabaena flos-aquae var. *Treleasii* Born. & Flah.

Tippecanoe County: Net collection from Hadley's Lake near Klondyke, no. 2831, July 11, 1959.

The vegetative cells are smaller and the spores much longer in this variety (spore up to 60 μ in length) than in the typical variety.

Anabaena unispora Gard.

Steuben County: Net collection from Gentian Lake, 6 mi. north of Angola, no. 2661, Aug. 24, 1953.

This species is typically a hard-water plankter in lakes of glacial origin in Indiana, very rare and found sparingly in the two collections at hand.

Arthrospira Gomontiana Setch.

Marshall County: Surface plankton. Kreighbaum Lake, Aug. 7, 1953. Collected by William R. Eberly.

This is a pseudovacuolated species.

Arthrospira Jenneri Stitzenberg.

Steuben County: Lake Lonidaw in Pokagon State Park, July 26, 1949 and Aug. 9, 1949. Collected by Sarah Ann Joyner.

This is not a new species report. The tightly intertwined nature of some of the filaments is of interest and the only readily available drawing of this phenomenon is in Prescott (5).

Dichothrix Orsiniana (Kütz.) Born. & Flah.

Cass County: A purplish colored crust on limestone in abandoned section of Cass Stone Co., 6 mi. west of Logansport, nos. 2994, 2996, June 29, 1961.

Phormidium mucicola Naum. & Huber.

Kosciusko County: Beaver Dam Lake, 4 mi. northwest of Silver Lake, no. 82, June 10, 1939.

This organism is occasionally found to be abundant in the gelatinous matrix of *Anacystis cyanea* (Kütz.) Dr. & Da.

Symploca Muscorum (Ag.) Gom.

Randolph County: From Grassy Sedge Knoll, Cabin Creek Raised Bog, 6.3 mi. north of Modoc, June 16, 1962.

This alga is cited here only because it is an addition to the algal flora of the Cabin Creek Raised Bog (2).

Rhodophyceae

Asterocytis smaragdina (Reinsch) Forti.

Warren County: In a thin yellow-brown layer of mud, Kickapoo Falls, Attica, nos. 2985, June 23, 1961, and 3022, 3028, 3026, 3020, Aug. 31, 1961.

This rhodophycean was previously collected in Lake County by Dr. Francis Drouet. I (1) stated that there was some doubt as to whether or not this was a rhodophycean or a myxophycean. When the Kickapoo Falls algal filaments were studied in the living condition, the single stellate chromatophore of a bright blue-green color with a single large pyrenoid at its center was extremely vivid. After these collections were dried down on mica or preserved in 2% formalin, they resembled the Lake County specimen. At least morphologically, these plants are rhodophycean and bear little resemblance to the myxophyceae except when seen in the dried or liquid-preserved condition.

Lemanea (Beck's Mill type sensu C. M. Palmer). See Palmer (3).

Lawrence County: Attached to concrete sluiceway in dam, in dripping water, State Fish Hatchery, Avoca, no. 2303, Aug. 1, 1950.

Several of the filaments in these plants measure 50 cm. or approximately 20 inches in length. Palmer (3) noted the greatest length for Indiana *Lemaneas* to be only 20 cm. or about 8 inches in length and G. M. Smith (6) claimed the same for the United States. The remainder of the *Lemanea* plants on the dam and attached to the stones in the streamlet below the dam were the usual small size of approximately 4 to 6 inches in length. The maximum internodal length of these large specimens is scarcely 3 mm. and this agrees with Palmer's measurements for Indiana plants. Thus, the gigantic oversize cannot be attributed to lengthened internodes.

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Analysis of an Original Forest of the Lower Wabash Floodplain and Upland

ALTON A. LINDSEY, Purdue University

The Smithsonian naturalist Robert Ridgway, by means of letters and photographs sent to Charles C. Deam (1, 3) and by size measurements of trees and general descriptions of communities (5, 6, 7), substantiated his claims as to the extraordinary nature of the Lower Wabash Valley bottomland forests *circa* 1870. None of the stands in this region recently analyzed by Lindsey *et al.* (3) represented the original type which Ridgway depicted, and it appeared that every example of such superb timber had been sacrificed, necessarily or unnecessarily, to the march of our culture. Fortunately, however, one sizeable remnant of this forest still stands. Although the timber has been marked for cutting, a campaign to raise funds for its purchase and preservation, aided by the Nature Conservancy, is underway in Illinois.

Beall Woods, near the village of Keensburg, Illinois, comprises 279 acres on both sides of Sugar Creek, Wabash County. (The narrow western lobe across the road, aside from a few remaining large trees, is hardly better than an ordinary cut-over woodlot; it is not included in this report.) The floodplain of Sugar Creek where it meets the Wabash is 400 feet above mean sea level. The floodplain surface varies about 3 feet in elevation, but since it lacks clear differentiation, of either physiographic or vegetational sort, into first and second terrace, the bottomland stand will be treated as a single community. The bottomland portion is on Genessee soil.

The ecoclimate of the Mt. Carmel area has been discussed earlier (3).

Field expenses were defrayed by a resarch grant (G 15568) from the National Science Foundation for study of pre-settlement-type forests.

Procedure

The one-fifth acre areal strip was the sampling unit used. Twenty such strips were applied in the floodplain forest, and 25 strips in the upland. Each strip was 200 feet long, surveyed by a central steel tape of that length, and 43.56 ft. wide. The width was not marked by surveyed boundaries; the more efficient method (2) of checking only the borderline trees was used, by twice laying out, at 90° to the center line, a stick of quarter-round 10.89 feet long. Most tree centers are obviously inside or outside the 21.8 foot half-strip width by estimation, and need not be checked for distance by use of the stick.

Each fifth-acre strip plot has 8 times the area of the 10 x 10 meter quadrat which has been used in many investigations in Midwest forests. Placement of strips was roughly stratified-random. Diameters (of all live trees at least 4 inches dbh) were measured to inches and tenths by diameter tape at 4.5 feet aboveground.

Frequency was based on tenth-acre strip sections, i.e., on 100 x 43.5 foot plots. Therefore, the straight frequency (F_1) figures are not comparable with F_1 percentages derived from smaller quadrats by other workers and are not reported here, but the relative frequency (F_3) percentages are comparable with F_3 from other size areal plots, and are presented. Detailed definitions of the vegetational attributes used may be found in Lindsey *et al.* (3), Table 3.

TABLE 3. Upland stand analysis, showing absolute attributes of first 20 species and their relative attributes as per cent of entire stand. (See legend of Table 1 for symbols). Figures rounded from 5 places.

	B_2	B_3	D_2	D_3	F_3	Y_3
Quercus alba	73	48	27	24	17	30
Acer saccharum	15	9.6	29	25	12	15
Q. velutina	15	9.6	6.2	5.3	5.6	6.9
Q. rubrum	8.0	5.3	2.3	2.0	3.5	3.6
Carya ovata	7.6	5.0	7.8	6.8	6.3	6.0
Fraxinus americana	6.5	4.3	5.3	4.6	6.6	5.2
Q. shumardii	6.0	4.0	1.2	1.0	2.1	2.4
Nyssa sylvatica	5.8	3.8	3.2	2.7	3.5	3.3
Q. bicolor	3.9	2.6	1.5	1.3	1.0	1.6
Carya ovalis	2.3	1.5	3.0	2.6	5.6	3.2
Other Carya*	2.0	1.3	2.0	1.7	—	—
Liquidambar styraciflua	1.4	0.9	2.2	1.9	3.8	2.2
Ulmus americana	0.94	0.62	3.5	3.0	1.4	1.7
Carya glabra	0.83	0.55	1.2	1.0	2.1	1.2
Fraxinus pennsylvanica	0.65	0.43	2.0	1.7	1.7	0.78
Celtis occidentalis	0.61	0.40	2.5	2.2	4.2	2.2
Cornus florida	0.56	0.37	4.8	4.2	5.6	3.4
Ostrya virginiana	0.46	0.30	3.8	3.3	4.5	2.7
Sassafras albidum	0.36	0.24	2.2	1.9	2.4	1.5
Prunus serotina	0.29	0.19	1.7	1.4	2.1	1.2
Cercis canadensis	0.13	0.09	1.2	1.0	2.8	1.3
Other species*	0.97	0.64	2.0	1.7	—	—
Stand values	B_9 152	—	D_9 115	—	—	—

* *Carya laciniosa, C. tomentosa, C. cordiformis, Juglans nigra, Quercus imbricaria, Q. muehlenbergii, Tilia americana, Ulmus rubra, Fagus grandifolia, Morus rubra, Vitis* sp.

Results on Floodplain Forest

Thirty-one tree species occurred on the bottomland (Table 1), including *Populus deltoides* which fell outside the sampling units. Two species, *Quercus shumardii* and *Liquidambar styraciflua* contributed 40% of the stand basal area, and with the next two species made up slightly more than 60%. Both basal area and importance percentage type this as an oak-gum-elm-hickory forest. *Ulmus americana* has by far the highest importance percentage (21) but ranked only fourth in basal area, since there were many small, widely scattered trees and only one large individual sampled (Table 2).

TABLE 1. Bottomland stand analysis of tree stratum (4" +) showing absolute attributes of first 18 species and their relative attributes as per cent of entire stand. B_2 is basal area in square feet per acre, B_3 relative basal area, D_2 is density per acre, D_3 relative density, and Y_3 is importance percentage. Figures rounded from five places.

	B_2	B_3	D_2	D_3	F_3	Y_3
Quercus shumardii	49	25	7.8	6.8	7.9	13
Liquidambar styraciflua	31	15	8.2	7.2	9.5	11
Quercus macrocarpa	22	11	3.8	3.3	5.8	6.7
Ulmus americana	19	9.8	41	36	18	21
Carya laciniosa	16	8.2	9.0	7.9	11	8.8
Acer saccharinum	10	5.2	8.3	7.2	4.7	5.7
Quercus palustris	9.9	5.0	1.5	1.3	2.6	3.0
Q. bicolor	9.5	4.8	2.0	1.7	3.7	3.4
Q. falcata var. pagodaefolia	7.2	3.6	1.2	1.1	2.1	2.3
Carya cordiformis	5.0	2.5	2.0	1.7	3.7	2.7
Betula nigra	3.0	1.5	1.0	0.87	1.1	1.2
Ulmus rubra	3.0	1.5	1.0	0.87	1.6	1.3
Platanus occidentalis	2.9	1.5	0.75	0.65	1.1	1.1
Fraxinus pennsylvanica	2.4	1.2	3.7	3.3	2.1	2.2
Carya ovata	2.3	1.2	2.5	2.2	3.2	2.2
Celtis occidentalis	1.6	0.8	8.5	7.4	8.4	5.5
Sassafras albidum	0.53	0.27	2.0	1.8	1.6	1.2
Cercis canadensis	0.05	0.03	2.7	2.4	3.2	1.9
Other species*	3.9	——	7.0	——	—	—
Stand values	B_9 199.	——	D_9 114.5	——	—	—

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* *Juglans nigra, Ulmus racemosa, Carya glabra, C. tomentosa, C. illinoensis, C. aquatica* (?), *Gleditsia triacanthos, Acer negundo, Diospyros virginiana, Gymnocladus dioica, Crataegus* sp., *Fraxinus americana.*

Although the stand is unusually mixed for bottomland timber, *Acer saccharinum, Betula, Platanus, Populus,* and *Carya illinoensis* are confined to the lowest spots, i.e., floodflow troughs and the edges of the floodplain along Sugar Creek. Six of the 20 strips represented this low end of the elevational gradient.

Table 2 gives the size class distribution for the major species separately, and for several minor ones lumped together. The proportion of large trees is very high; this applies from the 30 in. size class on up. The 18-26 inch classes are poorly represented. These points were brought out by plotting the totals (Table 2, bottom row) for the size classes on semi-log paper.

The mean diameter of floodplain trees was 13.7 inches, the stand density was 114.5 trees per acre, and the stand basal area 199 square feet per acre. The latter figure is the highest I know of for any old-growth hardwood stand in the Midwest.

TABLE 2. Species density per acre of bottomland stand by 4 inch size classes, indicated by size-class midpoints heading the columns. Species abbreviations refer to species names in Table 1.

	6	10	14	18	22	26	30	34	38	42	46
Qs	—	—	—	.25	—	1.25	1.75	1.75	1.25	1.25	.25
Ls	1.5	1	0.5	.25	0.5	0.25	1.75	1.25	0.5	—	—
Qm	.25	—	—	—	.25	.75	0.5	.75	.25	.5	—
Ua	20.	7.5	4.25	1	1	—	—	—	—	.25	—
Cl	1.5	2.25	1.75	1.2	1	0.5	1	—	.25	—	—
Asi	4.25	2.25	1.5	—	—	—	—	—	.25	.25	.25
Qp	—	—	—	.25	—	.25	—	.25	.25	.5	—
Qb	.25	—	—	—	.25	0.5	0.5	—	.25	.25	—
Qfp	—	—	—	—	—	.25	.25	.25	—	.25	—
CC	.25	.25	—	.25	0.5	0.5	.25	—	—	—	—
Bn	—	—	.25	.5	—	—	—	—	.25	—	—
Ur	1.25	0.5	—	.25	.25	0.5	—	—	—	—	—
Po	—	—	—	.25	—	—	0.5	—	—	—	—
Fp	3.0	—	.25	—	—	—	—	.25	—	—	—
Cov	.25	1.25	0.5	—	—	—	—	—	—	—	—
Coc	7.5	.75	—	—	—	—	—	—	—	—	—
Others	9.0	2.0	0.5	.25	0.5	—	—	—	—	—	—
Total	49.	24.5	9.5	4.45	4.	4.75	6.5	4.5	3.25	3.00	0.5

Results on Upland Forest

Thirty tree species at least 4 in. dbh were tallied from the 5 upland acres included in the sampling strips and tabulated in Table 3. The prominence of *Quercus alba* is clearly shown. Although *Acer saccharum* ranked second only to *Q. alba* in both importance and basal area, only one individual of its normal associate *Fagus* was recorded. All species of hickory combined showed lower than the maple in both importance and basal area, but the dominance of *Quercus alba* and of oaks in general (more than 70% of B_3) suggests the designation of oak-hickory-maple for this stand. The low importance of other trees contraindicates the mixed mesophytic type.

Table 4 gives the size class distribution in the upland stand, from the same 25 fifth-acre strips. Sugar maple was remarkably limited to the two lowest size classes, while oaks were almost as strikingly sparse in those 6 and 10 inch classes.

TABLE 4. Species density per acre of upland stand by 4 inch size classes, indicated by size-class midpoints heading the columns. Species abbreviations refer to species names in Table 3.

	6	10	14	18	22	26	30	34	38
Qa	1.8	3	3.6	7.4	5	6.2	3.2	1.8	0.8
As	31	3	0.2	—	0.4	—	—	—	—
Qv	0.2	0.6	1	1.4	1.4	1	0.4	0.4	—
Qr	0.2	—	0.2	0.2	1	0.6	0.8	—	—
Cot	1.2	3.2	3.4	1.4	1	—	—	—	—
Fa	3	0.6	1	0.4	0.2	1.2	—	—	—
Qs	—	—	—	—	—	0.4	0.6	0.2	0.2
Ns	0.4	0.6	0.4	1.2	0.6	0.6	—	—	—
Qb	—	—	0.2	—	0.6	0.2	0.2	—	—
Col	0.6	1.8	0.8	0.4	—	—	—	—	—
Cfl	6	—	—	—	—	—	—	—	—
Ls	2	—	—	0.2	0.2	—	—	—	—
Fp	1.6	0.8	0.4	—	—	—	—	—	—
Dv	5	—	—	—	—	—	—	—	—
Ss	2.6	—	—	—	—	—	—	—	—
Ps	1.2	0.4	—	—	—	—	—	—	—
Others	8	1.6	0.8	—	0.4	—	—	—	—
Total	64.6	15.6	12	12.6	10.8	10.2	5.2	2.4	1

The mean diameter of trunks in the upland stand was 12.8 inches, the stand density was 115 trees per acre, and the stand basal area 152 square feet per acre. Although the density was identical with that on the bottomland, the upland had a stand basal area only 76% of the bottomland basal area.

Largest Individual Trees

Maximum measurements of large species in the floodplain stand were: *Platanus*, 55.2 in. dbh; *Quercus macrocarpa*, 53.0; *Q. shumardii*, 49.6; *Fraxinus pennsylvanica*, 49.1; *Q. palustris*, 44.1; *Ulmus americana* (dead), 45.3; *Liquidambar*, 43.6; *Acer saccharinum*, 44.3; *Q. bicolor*, 41.7; *Carya illinoensis* 36.8, and *Populus deltoides*, 31.3.

On the upland, some maximum species figures were: *Quercus alba*, 40.1 dbh; *Q. velutina*, 38.2; *Fraxinus americana*, 33.6, *Nyssa*, 26.7, and *Sassafras*, 21.2.

There may be larger trees that were not within the sample units nor encountered outside them. The report of the timber cruise, when trees were marked for cutting, included a 62 inch *Q. macrocarpa* measurement. I did not see this tree.

Professor Elroy Rice helped me take some of these diameters on a preliminary visit to the stand.

Discussion

Like Donaldson's Woods (2), a virgin stand of white oak-beech-maple in Spring Mill State Park, Lawrence County, Indiana, Beall Woods upland is clearly gravitating toward a less xerophytic dominance as indicated by the heavy sampling in lower size classes and observations on reproduction less than 4 inches dbh. That two best examples of oak-dominated old-growth forests between the 38 and 39 parallel in Indiana and the Wabash Valley share this trait is a challenging fact. Are these stands, which are as undisturbed as it is possible to find for their type, actually preclimax under present climate? Less technically put, are they stands which, even though essentially "virgin stands" (especially Donaldson's Woods), have not yet reached the climatic type under current climate? The advance of the mesophytic *Acer* strongly indicates a late stage of succession rather than a stabilized condition. Paradoxically, the climatic trend that occurred during this successional period is generally agreed to be toward more warm-dry climate, or counter to that which would be expected to promote succession favoring *Acer saccharum*. Although this may have been too minor to affect vegetation in this respect, at least the changes in these stands cannot be attributed to climatic changes as causal.

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PSYCHOLOGY

Chairman: S. M. Berger, Indiana University

William Martin, Purdue University, was elected chairman for 1963

ABSTRACTS

Watson, Jennings, and the Biological Origins of Behaviorism. Donald D. Jensen, Indiana University.—There is evidence that J. B. Watson, who is usually considered to have founded psychological behaviorism in 1914, was strongly influenced by H. S. Jennings, a biologist who published extensively on the behavior of lower organisms from 1896 to 1908. Jennings held that "no statement concerning consciousness in animals is open to verification or refutation by observation and experiment.—All that experiment and observation can do is show us whether the behavior of lower organisms is objectively similar to the behavior that in man is accompanied by consciousness." In 1905 and 1907 Watson criticized Jennings' approach from a definitely introspectionistic point of view. In 1908 Watson moved to Johns Hopkins where Jennings was, met and took courses under Jennings, and collaborated with K. S. Lashley who was completing his dissertation on genetics under Jennings. In 1913 and 1914, Watson's first behavioristic works appeared, without, however, acknowledgment of association with or debt to Jennings. It seems evident that psychological behaviorism is simply an extension to man and higher animals of a methodological point of view developed by Jennings in the behavior of lower organisms.

Transfer of Learning without Verbal Understanding. Julius Sassenrath, Indiana University.—Last year at the IAS meeting experimental evidence for the automatic action of verbal reinforcers was presented. The present paper offers more recent corroborating evidence on this general issue. The major purpose of the present experiment is to determine whether a principle being learned without awareness (LWA) or without verbal understanding during a training period will facilitate learning a second principle during a transfer period. The major results indicate that groups which show LWA during training: (a) require fewer blocks of trails to learn the transfer principle and (b) show a larger number of correct responses during the transfer period than do the control groups. Presumably, then, LWA in training can influence the acquisition of a transfer task.

An Exprimental Comparison of Graduate and Undergraduate Performance in Educational Psychology. Robert Snodgrass, Purdue University.—A comparison was made of the average performances of graduate students with that of undergraduates in regular classes of educational psychology. The experiment was made during school years 60-61, 61-62, with 1,005 undergraduate and 250 students, with six separate classes at each of the two levels. Both graduates and undergraduates received identical instruction for certain topics. Objective test items covering this instruction were included in the regular tests administered to both groups, and were scored separately. The means for both groups were compared. In on-campus classes, graduate performance was better (CR = 2.0). In summer classes there was no difference. In evening classes, undergraduate performance was better (CR = 3.6). Over-all the undergraduate was apparently better but statistically insignificant.

Vicarious Instigation, Conditioning, and Frequency of Apparent Shock to the Performer. SEYMOUR M. BERGER, Indiana University.—Observer responses to the apparent shock of someone else were measured on the pleasant-unpleasant scale of the semantic differential. Three groups of 14 observers each, watched a person apparently receive either 1, 5, or 9 shocks. Observers rated their own feelings as increasingly unpleasant as the number of shocks increased ($p<.05$); their ratings differed from control groups which observed no shocks ($p<.01$). Previous studies using the GSR found a decrease in observer arousal over trials. This investigation suggests an artifact of GSR adaptation in the previous studies. The findings do not support a conditioned emotional response explanation of vicarious instigation.

Programmed Tutoring of Elementary Reading. DOUGLAS G. ELLSON, Indiana University.—This paper reported preliminary results from six experiments utilizing a programmed learning technique based upon a paired associates method to teach reading vocabulary at the first grade level. Experimental subjects in all cases were retarded and normal children. Results obtained so far do not support the common belief that children with low IQ's form associations more slowly than normals. There are indications of other factors that contribute to the poor performance of retardates. The highest rate of vocabulary acquisition was found for retarded children with a reading background, the slowest for normal children during their first weeks in the first grade. The experiments also indicate that programmed teaching can be carried out by relatively untrained tutors including those labeled "retarded" and that programmed learning was most effective in combination with classroom teaching. Approximately ninety percent retention has been found in tests one month and one year after acquisition. In general the results of these experiments demonstrate the feasibility of effective teaching of reading vocabulary to retarded and normal children by programmed learning techniques.

Programmed Instruction in Beginning Reading. DONALD G. DOEHRING, Ph.D., Institute of Psychiatric Research, Indiana University Medical Center.—A preliminary investigation of programmed instruction in beginning reading has been completed. Reading material in the form of simple sentences, single words, and phonic sounds was systematically presented by means of a multiple-choice visual instructional device and tape-recorded auditory stimuli. A sight-reading program was administered to four normal and five mentally-retarded beginning readers, and a phonics program was administered to one of the normal children. Results suggest that the use of systematic instructional techniques may enable us to delineate a hierarchy of subordinate skills necessary for the development of reading behavior.

Effect of Nonoptimally High Incubation Temperature on Frequency of Pecking and on Color Preferences in the Chick[1]

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Introduction

In summarizing a series of studies concerned with the relationship between time of conception and mental deficiency, Pasamanick, Dinitz, and Knobloch (9) report a higher incidence of mental deficiency among children who were conceived during the late spring and early summer. These investigators suggest that the stress of summer heat during the critical embryonic period for central nervous system development may have been an etiological factor in these cases.

Gunther (2) has pointed up the feasibility of evaluating a possible relationship between behavioral anomalies and temperature stress during embryonic development through the use of the chicken in animal analogue investigations. By subjecting chicken eggs to nonoptimally high incubation temperatures during both the initial and terminal phases of the incubation period, it has been found that these higher temperatures produce various types of structural and behavioral abnormalities in the subsequently hatched animals (6) and also depress performance on certain learning tasks (4). In addition, Gunther and Jones (3) have found that nonoptimally high incubation temperatures result in lower body weight at hatching and also in reduced rates of posthatching weight gain.

The present study represents an attempt to assess the effects of nonoptimally high incubation temperature on pecking frequency and on color preference in the chick.

Materials

Subjects

All control and experimental animals used in the study were Cornish White Rock chicks. Control animals were hatched from eggs incubated at the optimal temperature of 37.5° C. for the entire incubation period. Experimental animals were hatched from eggs incubated at the nonoptimally high temperature of 41° C. for the first 72 hours of the incubation period and at the optimal temperature for the remainder of the period. Previous investigation suggested that maximally deleterious behavioral effects are achieved at this nonoptimally high temperature. With incubation temperatures higher than 41° C., or with temperatures between 37.5° C. and 41° C. employed over periods longer than the first three days of incubation, the mortality rate during incubation is inordinately high. The pre-experimental histories of the animal subjects are described in detail in appropriate sections below.

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Apparatus

Pecking apparatus. The apparatus employed was similar to one described by Hess (8). It consists of a large octagonal wooden box, the interior of which is painted a neutral gray. The floor of the box is covered with a wire-mesh screen which can be raised or lowered to accommodate chicks of different sizes. The apparatus is supported from the floor by legs, 24 inches high. Illumination of the interior of the box is provided by a 200-watt incandescent light bulb suspended 32 inches above the floor. To prevent the animals from escaping from the apparatus, the top is covered with a removable chicken-wire screen during testing. A removable wooden partition renders it possible to divide the interior of the apparatus into two sections of equal size. To eliminate extraneous visual stimuli during testing, the apparatus is surrounded by a thin, gray percale curtain.

On each of the eight side panels of the box is a metal receptacle containing two round holes through which the stimuli are presented at the ends of clear plastic cylinders which protrude through the holes. The metal receptacles are fitted flush with the side panels and are painted a neutral gray to render them homogeneous with the remainder of the interior of the box. Since each receptacle displays two stimuli, the entire apparatus permits the simultaneous presentation of 16 different stimuli. The stimuli are presented by attaching them to the insides of the clear plastic ends of the plastic cylinders which are then fitted into the round holes in the side panels. The other end of each plastic cylinder is attached by means of a screw to the lever of a microswitch at the back of the panel. Each switch (No. Bz- 2RW 8435- A2, Microswitch Company) is wired individually to an automatic counter. Thus, each stimulus cylinder, switch, and counter functions as a unit. When an animal pecks at a stimulus, the plastic cylinder and switch lever are moved backward, closing the switch and causing the counter corresponding to that switch to move ahead one integer. In this way, automatic recording of responses is accomplished.

The following are the dimensions of the pecking apparatus: diameter of inscribed circle, 43.5 inches; area of floor space, 10.9 square feet; wall height of box, 15 inches; length of each of the eight panels, 18 inches; size of faces of metal receptacles, 2.75 inches high by 7.37 inches wide; size of holes in receptacle into which plastic cylinders are fitted, 1.06 inches; distance separating holes in each receptacle, 3 inches. The temperature inside the apparatus was maintained at 28° ± 2° C.

Stimuli. Two types of stimuli, designed to simulate food objects, were employed in the tests of pecking frequency. A circular disc, ¼ inch in diameter, was cut from black construction paper and fastened to the center of the inside of the plastic end of each cylinder by means of transparent tape. The second type of target used to test pecking frequency was constructed by filling each clear plastic cylinder with Purina Starter Mash, the only food with which the animals had experience.

The stimuli employed in testing color preference consisted of ¼ inch discs, cut from 16 of the colored chips from the Ostwald Color

Harmony Manual (1). The 16 colors used were the same as those employed in a study of color preferences in chicks and ducklings by Hess (8). In this study, Hess selected these particular 16 colors in order to explore as much as possible of the chick's visible spectrum. The finest gradations among the colored stimuli, in terms of wave length, appear in regions where greatest sensitivity is thought to exist. The stimulus discs were cut from the following fully saturated Ostwald chips: 1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 13, 14, 16, 19, 22, and 24. Each disc was attached at the center of the inside of the clear plastic end of each cylinder in such a manner that its dull side was presented to the animals in the apparatus. The colorimetric properties of the 16 chips under illuminant C are given in Table 1. All of the hues are spectral colors, except chips 8, 10, and 12; the wave length given for each of these three stimuli is the wave length of the complementary color.

TABLE 1
Colorimetric specifications of Ostwald color chips
under Illuminant C

Chip Number	Wavelength	Reflectance (%)	Purity (%)
1	572.4	68.8	80.8
2	577.8	63.0	85.2
3	581.9	51.7	85.6
4	588.0	39.5	83.0
5	592.7	32.4	81.0
6	601.2	21.7	75.0
7	617.0	13.5	59.6
8	494.1c	12.7	40.5
10	523.0c	10.0	44.2
12	565.9c	8.8	38.6
13	469.0	10.1	69.4
14	477.0	13.2	59.5
16	484.2	16.0	47.2
19	491.7	16.7	37.0
22	527.0	22.8	28.0
24	562.7	48.7	70.0

c = non-spectral color, wavelength given is that of complementary

Procedure and Results

Tests of Pecking Frequency

Chicks from 3 different lots were used in these tests. Each lot consisted of one control group and one experimental group of animals. Lot A was hatched in June, Lot B in July, and Lot C in August. The animals in all three lots were tested during the months of July and August and were subjected to approximately 14-hour deprivations of food but not water before each test session. Prior to being tested, the animals in all 3 lots had been run on learning tasks which required their being handled daily. All chicks within a given lot had been subjected to the same learning situations and had equal amounts of experience in these situations. Chicks in Lots A, B, and C were tested with the black disc targets, while only chicks in Lots B and C were used in tests in which the pecking targets consisted of food in the form of mash visible through the ends of the transparent plastic cylinders.

During each test session the wooden partition was used to divide the interior of the apparatus into two compartments of equal size, each with a total of 8 pecking targets. The test periods varied in length both within and among the lots. However, during each test period, control and experimental groups composing a particular lot were tested simultaneously in the apparatus and were placed in each of the 2 compartments for equal periods of time.

Although tests were run almost daily throughout the months of July and August, only the data for 6 representative test sessions are reported. Table 2 indicates for both types of pecking targets the total responses delivered by control and experimental groups within each lot, the ages of the animals at testing, the number of animals in each group, the number and length of trial periods for each lot, and the values of chi-square based upon the differential response frequencies of experimental and control groups of each lot.

It is seen that each value of chi-square is significant at beyond the .001 level of confidence, the control animals delivering the greater number of responses in each case. There is a tendency for these values to decrease with increasing age of the chicks, but they remain highly significant when the birds are 52 days of age, in the case of the black disc targets, and when the birds are 53 days of age, in the case of the targets consisting of mash in the plastic cylinders. In a previous investigation (3), it was found that chicks hatched from eggs which had been subjected to nonoptimally high incubation temperatures showed significantly lower posthatching body weight and reduced rates of weight gain when compared with controls. In view of the findings of the current study, it was felt that experimental aniamls may possibly ingest smaller quantities of food than do control animals, and that this might be a factor related to the reduced weights and rates of weight gain observed earlier. Accordingly, the amount of food ingested by the animals of Lots B and C was measured during several free-feeding periods when the animals were between 30 and 45 days of age. Tests of significance of difference between mean amounts of food ingested by experimental and control groups in these 2 lots elicited only very low non-significant values.

Color Preference Test

Forty-five control and 45 experimental aniamls were used in this test. These chicks composed Lot D and were 9 days old when tested. The animals were not experimentally naive, since at 5 and 6 days of age they had been introduced to the 16 color stimuli in tests designed to determine the effects of nonoptimally high incubation temperature on proclivity for preferred versus non-preferred colors. All animals were deprived of food but not water for about 13 hours prior to testing.

TABLE 2

Conditions and Results of Tests of Pecking Frequency on Experimental and Control Groups of Lots A, B, and C
Targets: Black Discs

Lot	Group	Total Responses	Age (days)	n	Chi-square (1 df)	Conditions
A	Control	12,604	12	41	10,199.46*	Two 1-hour trials
	Experimental	877	12	41		
B	Control	5,074	19	24	1,543.14*	Two 2¾-hour trials
	Experimental	1,813	19	24		
C	Control	5,854	52	11	1,271.08*	Two 4½-hour trials
	Experimental	2,579	52	11		
		Targets:	Starteena Mash in Transparent Plastic Cylinders			
B	Control	26,748	22	24	9,361.96*	Four 1½-hour trials
	Experimental	7,557	22	24		
B	Control	3,422	33	24	72.96*	Two 1½-hour trials
	Experimental	2,753	33	24		
C	Control	3,883	53	11	503.16*	Two 1½-hour trials
	Experimental	2,141	53	11		

* Significant at beyond .001 level of confidence.

All 16 color stimuli were employed, a different color being situated at each of the 16 target locations. A total of 16 half-hour trial periods was administered. During each half-hour period, experimental and control groups were each exposed to the color stimuli for 15 minutes. At the end of each half-hour period, the positions of the stimuli were randomized among the 16 target locations. The testing was done in August, and the total time required to administer the 16 periods was approximately 14 hours.

The total numbers of responses delivered to each of the 16 stimuli by control and experimental groups are given in Table 3. As was found to be the case in tests of pecking frequency, the total numbers of responses delivered by control and experimental groups differ markedly, and this difference is highly significant statistically. Fig. 1 is a frequency polygon showing the relative percentage of total responses plotted against the decreasing wave length values of the stimuli. It is seen that the highest percentages of responses by the control group were delivered to stimuli in the orange and yellow regions of the spectrum, while the highest percentages for the experimental group occur in the green-blue region. An overall chi-square (10) based on the differential frequencies of response between control and experimental groups for all 16 stimuli elicited a value of 534.55, significant at beyond the .001 level of confidence. The results of chi-square tests, based on

TABLE 3

Total Responses Delivered by Control and Experimental Groups of Lot D

Chip number	Responses by control group	Responses by experimental group
1	3,776	24
2	8,022	44
3	5,686	50
4	1,742	26
5	2,821	26
6	1,627	31
7	1,083	25
8	988	23
10	964	20
12	738	22
13	785	47
14	1,504	77
16	540	50
19	479	26
22	1,225	25
24	1,904	39
Total	33,884	555

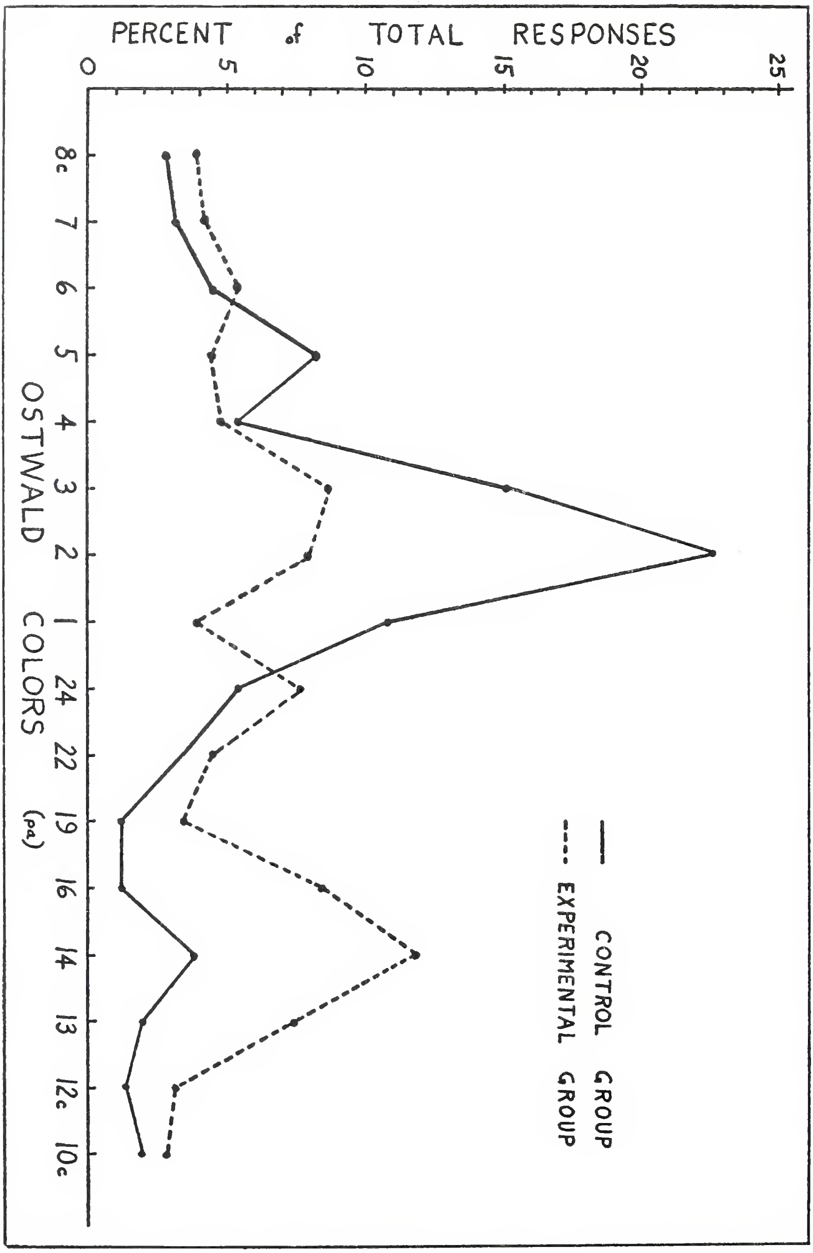

Figure 1 Percentage of total responses delivered by control and experimental groups of Lot D.

percentage differences in response between control and experimental groups for each color stimulus, indicated that the group percentage differences for the following stimuli are significant at or beyond the .01 level of confidence: 1, 2, 3, 5, 12c, 13, 14, 16, and 19. The results of these tests indicate that the group differences in relative preference for stimuli in the two spectral regions noted above are significant.

Discussion

The finding that groups of experimental animals delivered consistently lower numbers of responses than controls in tests of pecking frequency suggests several hypotheses concerning the nature of the effect of the temperature insult on the experimental chicks. In an earlier study (4) in which nonoptimally high incubation temperature was found to depress the chick's ability to learn under food deprivation an alternation pattern in the T-maze, it was considered possible that the higher incubation temperature may have more or less permanently reduced the motivational level of the temperature-stressed animals. The finding in the present study of ingestion of equal amounts of food by control and experimental animals during free-feeding would appear to cast doubt on the tenability of any hypothesis of reduced hunger drive in the experimental animals.

Gunther and Jones (3) have found lowered mean weights and reduced rates of weight gain in chicks hatched from eggs incubated for various periods of time at nonoptimally high temperatures. In considering possible underlying mechanisms which might have mediated these findings, the most plausible appeared to be protein denaturization of one or several enzymes which may have resulted in reversible or irreversible injury to the enzyme systems involved. On this hypothesis, the reduced pecking rates of the experimental animals in the present study may have been related to a generalized pathological effect of the temperature insult on several or possibly all types of tissue.

Still a third possibility is suggested by the results of the color preference test in which experimental animals manifested altered responsiveness to color stimuli. It seems conceivable that the higher incubation temperature may have altered the peripheral and/or central visual apparatus in such a manner that acuity for visual stimuli was generally reduced in the experimental animals, resulting in reduced response rates on the part of these animals.

In the tests of pecking frequency, a tendency was noted toward reduction of the significance levels of the results of statistical tests with increasing age of the animals. This suggests the possibility that the effects of the temperature insult might be overcome at a more advanced age. It is intended to evaluate this contingency in future research.

In a study in which the experimental apparatus and procedure were closely similar to those employed in the color preference test of the present investigation, Hess (8) found no evidence to suggest that the purity or reflectance of color stimuli was effective in determining preferences of chicks for objects of different colors. The results of the present study appear to be in accord with those of Hess in that a comparison of the purity and reflectance values in Table 1 with the percentages of total responses delivered by control and experimental groups to the series of color stimuli (Fig. 1) does not disclose any greater effectiveness of the dimensions of purity and reflectance over color in either group.

It was found that control animals demonstrated a greater preference for stimuli in the yellow and orange regions of the spectrum, while experimental animals preferred pecking at green and blue stimuli. However, because of the relatively small response total of the experimental group, the reliability of these differences may be questioned. Assuming the differences to be reliable, speculation concerning underlying mechanisms which may have mediated the finding is appropriate.

Since the animals in both groups had been exposed to the color stimuli prior to testing, it is possible that experimental and control groups had been differentially imprinted on the color stimuli. In addition to the absence of an explanation of such differential imprinting, several other considerations would appear to detract from the plausibility of this hypothesis. In previous unpublished studies, the authors have found it difficult to imprint White Rock chicks on color stimuli under optimal imprinting conditions. In this connection Hess (7) had reported that the susceptibility of White Rocks to imprinting on various types of objects is considerably lower than that of other races of chickens. In addition, the pre-test exposure to the color stimuli in the present study occurred when the animals were at an age considerably beyond the optimal or "critical" period for imprinting in most fowl.

It is conceivable that the group differences in response to the color stimuli are related to structural changes which may have been produced in the peripheral visual apparatus by the temperature insult. For example, the differences may reflect an effect of the higher incubation temperature on retinal cones which mediate response to different spectral regions. The cones of the chicken retina contain red, orange, and yellow oil-droplets which are regarded as being responsible for the partial blindness for blue stimuli which is normal in the chicken. According to Walls (11), this partial blindness for blue increases with growth, presumably because of the deepening of pigmentations of the oil-droplets. In view of these considerations, a possible effect of the temperature stress on the experimental animals of the present study may have been to reduce the rate of deepening of oil-droplet pigmentation and/or to produce a reduction in the growth rate of these animals. In either or both of these cases, it might be expected that the experimental animals would show relatively greater sensitivity to stimuli in the blue region of the spectrum than would animals in the control group.

It is also conceivable that the differential response to color stimuli observed between control and experimental groups may have been a function of effects of the higher incubation temperature on more central visual mechanisms, or possibly on a combination of central and peripheral elements. For example, the undetermined neural bases of color preference behavior may have been involved.

At any rate, these results extend the number of different behavioral aberrations previously reported. Since temperature is the only variable (as far as is known at this time), it appears that further studies on human mental deficiency, such as those reported by Pasamanik, et al.

(9), based on temperature data may prove very fruitful. As more research is directed toward an experimental approach to mental illnesses, it becomes increasingly evident that the basic chemistry of brain metabolism is involved (5).

Summary

Experimental groups of chicks were hatched from eggs incubated at the nonoptimally high temperature of 41° C. for the first three days of the incubation period and at the optimal temperature of 37.5° C. for the remainder of the period. Control groups of chicks were hatched from eggs incubated at the optimal temperature for the entire incubation period. Comparisons between experimental and control groups were made by means of an apparatus which permitted automatic recording of responses delivered to pecking targets of different types.

With chicks of different ages and with pecking targets which resembled food objects, the spontaneous pecking frequencies for control groups were significantly greater than those for experimental groups at all ages tested. With chicks of the same age and with pecking targets consisting of objects of different colors, the experimental group delivered significantly higher percentages of responses to targets in the green-blue region of the spectrum than did the control group; the control group delivered significantly greater percentages of responses to targets in the yellow-orange region of the spectrum than did the experimental group. Underlying mechanisms which may have mediated these results were discussed.

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SOIL SCIENCE

Chairman: Dan Wiersma, Purdue University

Gerald E. Wilcox, Purdue University, was elected chairman for 1963

Tomato Response to Nitrogen Fertilization in Indiana[1]

Gerald E. Wilcox

Although nitrogen is one of the major nutrient elements often limiting tomato growth in Indiana, proper application rates have been uncertain. When considering nitrogen availability, factors such as crop rotations, previous crop, soil type, weather, past fertilizer treatments, variety and intensity of production must be taken into account.

Rotations with legume hay crops are known to build up the available soil nitrogen. Reeve et al. (1) found that tomato yields were essentially doubled by two years of deep rooted legumes in a four year rotation as compared with rotations involving only tomatoes and onion sets or continuous tomatoes. Many of the present rotations used on farms in the tomato producing area utilize row crops so that the soil may or may not be depleted of soil nitrogen depending upon the fertilizer practices followed.

Without nitrogen fertilization of the row crop preceding the tomato crop, the soil could be depleted of its available nitrogen supply. However, a corn crop that has received 150 lbs. of nitrogen the preceding year will carry over a large portion of the nitrogen in stalks that are plowed down and this can be used by the succeeding tomato crop.

These experiments were run to measure the response of tomatoes to nitrogen fertilization on different soil types and over a range of N rates that extend into excessive levels of N.

Materials and Methods

Nitrogen was applied as ammonium nitrate in all the tests. In 1957, nitrogen rates from 0-160 lbs/A in 40 pound increments were applied, as side-dressing after the first fruit cluster was set, on two locations, a gravelly, sandy loam soil near Columbus, Indiana and a Miami silt loam near Converse, Indiana. At Columbus, urbana tomatoes were set on soil that had been fertilized with 600 lbs. 5-20-20 plowed down and the plants received starter solution. At Converse, the tomatoes were direct seeded in the field with a 300 lb. application of 8-32-0 banded two inches to the side and two inches below the seed. In 1958, the Epoch variety, a dwarf type, was tested at 3 populations and three nitrogen levels, 50, 100 and 150 lbs/A added two weeks after the plants were set.

In 1960 the experiment was run on Tecumseh tomatoes direct seeded on an Ockley silt loam soil which is an alluvial terrace and outwash plain soil with slow surface drainage and good to excessive internal drainage. Four nitrogen treatments 25, 75, 125 and 525 pounds/A were applied broadcast just before the tomatoes were seeded on May 5. The treatments were replicated six times in randomized block design. The soil analysis was pH 6.2, available phosphorus averaged 234 lbs/A and available potassium was 277 lbs/A by the Purdue soil test. Four foot rows were used and 15 pounds per acre of 10-52-17 was applied directly on the seed at planting time. Five hundred pounds/A of 5-20-20 was plowed down prior to any treatment application. Six weeks after planting, the plants were thinned to a population of 8,712 plants per acre. Each plot consisted of four rows, 27 feet long and 25 feet of the two center rows of each plot was harvested for yield.

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The 1961 experiment was also conducted on an Ockley silt loam. The soil analyzed pH 6.3, P_2O_5 445 lbs/A and K20 346 lbs/A by the Purdue soil test. Nitrogen was applied at rates of 0, 50, 100, 200, 300 and 400 pounds per acre on corn stalks and plowed down in April. The six treatments were arranged in randomized blocks and replicated four times. Tecumseh tomatoes were direct seeded in four foot rows May 14, 1961 and fertilized with 5 lbs/A P as 10-52-17 applied directly on the seed. Due to the cold soil the seed did not come up until the first week in June. A stand of one plant every 12 inches was established in the plots. Flower cluster and fruit counts were made during the season and leaf samples collected for chemical analysis. The fruit was picked by hand in three pickings.

Results

In 1957, a significant response to the first increment of nitrogen was obtained at the Converse location, Table 1. There was little increase to the higher rates of nitrogen applied. At the Columbus location there was no response to the nitrogen applications. In 1958, the effects of nitrogen fertilization rate and plant population on the dwarf tomato yields are presented in Table 2. As the rate of side-dressed nitrogen was increased from 50 to 150 pounds per acre the yields were deceased over 3 tons per acre at the lowest and highest population. This decrease was attributed largely to the delayed maturation of the fruit. The 150

TABLE 1. Effect of Nitrogen on Tomato Yields, Converse 1957

	YIELD PER ACRE				
	Picking Date				
Nitrogen Applied	8/21	8/30	9/9	9/19	Total
lbs/A			Tons		
0	3.21	5.10	2.80	3.71	14.8
40	3.44	5.39	3.68	5.12	17.6
80	2.70	4.06	4.44	6.03	17.2
120	3.28	5.04	4.24	5.60	18.2
160	3.08	4.56	4.80	6.98	19.4
LSD p = .05	N.S.	N.S.	1.04	1.98	2.6

TABLE 2. Marketable Yields of Epoch Tomatoes at Various Populations and Different Nitrogen Levels; O'Neall Farm, Lafayette, Indiana, 1958.

Plants per acre	Nitrogen rate (actual N added)	Yield per acre			
		Picking			Total
		8/26	9/4	9/19	
	Pounds		Tons		
12,444	50	2.69	8.11	5.12	15.92
	100	1.04	7.77	5.41	14.22
	150	0.98	5.79	5.36	12.13
24,888	50	2.01	5.25	6.10	13.36
	100	2.36	7.77	6.19	16.32
	150	1.27	6.63	6.58	14.48
37,332	50	3.11	9.19	5.10	17.40
	100	2.99	7.43	6.61	17.03
	150	1.69	6.30	6.01	14.00

pound nitrogen rate resulted in abnormal vine growth for the Epoch variety and was more pronounced at the low than at the high populations.

The effect of nitrogen applications on the yield of Tecumseh tomatoes in 1960 is shown in Table 3. At the first picking the yield from the 25 pound N treatment was significantly higher than the yields obtained from the higher nitrogen treatments. However, at the second picking there was no significant difference between the four nitrogen treatments. The yield at the second picking for the 4 nitrogen treatments averaged 15.9 tons. At the third picking the yield from the 25 pound nitrogen treatment was significantly lower than the yield from the other three nitrogen levels. This was also true at the fourth picking. In a comparison of the effects of the nitrogen treatments on total yield, the

TABLE 3. Yield of Tecumseh Tomatoes, 1960

Treatment Rate of N Broadcast Preplant	Yield				
	1st Picking 8/26/60	2nd Picking 9/8/60	3rd Picking 9/22/60	4th Picking 10/6/60	Total
Lbs/A			T/A		
25	2.1	17.3	4.8	1.6	25.8
75	1.0	14.4	9.3	4.0	28.7
125	1.1	18.6	8.9	3.0	31.6
525	.8	13.5	11.1	5.6	31.0
LSD 5% Level	0.98	N.S.	3.1	1.5	4.6

highest yield was obtained from the 125 pound nitrogen treatments and this yield was significantly higher than that obtained from the 25 pound. The 525 pound nitrogen treatment resulted in a tomato yield of 31 tons which is almost identical to that of the 125 pound nitrogen. However, the 525 pound N rate delayed maturity somewhat and spread the harvest period.

In 1961, vine growth and color response to the first two increments of N were apparent throughout the season. The results of the fruit count made August 8 are listed in Table 4. A significant increase in fruit was obtained from N fertilization comparing the 0 and 50 N rates. Maximum number of fruit were set at the 200 pound N treatment while fruit numbers decreased at the highest N rate. Fruit cluster counts made July 24 did not show differences due to N treatment while one week later the clusters at the 400 pound N treatment were fewer in number than for the lower N treatments.

TABLE 4. Tomato Fruit Cluster Development, Fruit Set and Yield Response to Rate of Nitrogen Fertilizer Application

Treatment	Flower clusters per plot		Fruit per plot	Yield
N rate per acre	7/24	7/31	8/8	Per/A
lbs				T
0	74	186	495	17.5
50	88	199	638	18.1
100	88	208	617	17.2
200	96	209	725	16.6
300	87	195	656	16.5
400	64	165	564	14.5
LSD p=.05	N.S.	36	118	2.3

The yield, Table 4, from the 400 pound N treatment was lower than for the lower N rates. The moisture during 1961 appeared to be deficient, especially during the last three weeks of August when the fruit were developing. Severe blossom end rot developed on fruit in the 400 pound N plots. This appeared to be directly associated with the decreased yield for this treatment. There was no significant difference between yields at the lower N rates.

Tissue samples, from the 1961 test were analyzed and the results are presented in Table 5. The sample collected at the first blossom cluster stage, July 21, showed that the nitrogen fertilization increased the N and Mg composition of the tissue. Leaf tissue collected when the plant was carrying a fruit load showed the nitrogen fertilization decreased P concentration and increased N, Mg and Ca concentration in the tissue. Potassium was not affected by N fertilization at either sample date.

At the first picking date, September 11, a hamper of tomatoes, from each plot of the 0, 50 and 400 pound N treatments was graded and

TABLE 5. Composition of Tomato Leaves at Various Rates of N Fertilizer Application.

		Nitrogent fertilizer application, pounds per acre						
Nutrient	Sample Date	0	50	100	200	300	400	LSD p = .05
				%				
N	7/21	2.90	2.99	3.18	2.96	3.48	3.68	.58
	8/15	2.29	2.60	2.38	2.86	2.92	2.83	.25
P	7/21	.18	.18	.17	.15	.18	.18	N.S.
	8/15	.20	.18	.15	.17	.16	.14	.03
K	7/21	3.38	3.17	3.04	3.04	3.56	3.22	N.S.
	8/15	3.08	2.98	2.68	2.75	2.96	2.76	N.S.
Ca	7/21	3.72	4.06	4.04	4.14	4.39	4.10	N.S.
	8/15	4.34	4.50	4.75	4.71	4.84	4.85	.40
Mg	7/21	.95	1.08	1.10	1.18	1.23	1.20	.18
	8/15	.99	1.12	1.18	1.22	1.30	1.29	.14

analyzed for pH, dry matter and color. The results are presented in Table 6. The grade was not affected very much by N fertilization. The best grade tomatoes were from the 50 pound N treatment. The tomatoes from the zero treatment graded a lower percent number ones but had less culls.

TABLE 6. Quality measurements of tomatoes fertilized with various N rates.

		N	rate	lbs/A
Measurement		0	50	400
Grade				
#1	Fruit Number	298	328	305
#2		144	101	105
cull		75	92	111
#1	Fruit per cent	56	61	59
#2		29	20	21
cull		15	19	20
pH		4.3	4.3	4.3
Refractive index (Solids)		1.3432	1.3439	1.3440
Color	L	24.4	24.4	25.2
	a	20.4	19.2	21.3
	b	10.6	10.2	11.0

The pH, dry matter (R.I.) and color were not affected by the N fertilizer treatments.

Tests made on the plant sap during the growing season indicated very low N in the plants of the zero N treatment from seedling stage through the entire season. The plants that received 50 pounds N did not show deficiency until after fruit was developing.

Discussion

Nitrogen was found to be deficient in soils typical of those used in tomato production for processing tomatoes for growth of determinate vine-type varieties. The dwarf variety did not respond to nitrogen applications above 50 lbs/A. Although time and method of application was not a factor in this series of experiments observations between years to response to side-dressing or broadcast preplant applications showed that about the same response to rate of nitrogen applied was obtained regardless of the method of application. Preference is given, therefore, to the preplant broadcast method of application because it more nearly assures a nitrogen sufficiency during the vegetative developmental period of the plant. Also the plant growth rate and development is not upset by a sharp change in nitrogen concentration in the soil medium as might be brought about if the plant were growing in a deficient condition when the side-dressing application of nitrogen is applied.

It was observed that as the nitrogen rate was increased the vegetative growth of the tomato plant increased. Under a heavy fruit load visible nitrogen deficiency symptoms developed in the 0 and 75 pound per acre nitrogen range. Maximum yields were obtained for the nitrogen rate at which visible deficiency symptoms did not occur until after the plant was carrying its fruit load. However, extension of the N rate to excessive levels did not detrimentally affect fruit set or yield, with the exception of 1961 at a location of severe drought during the period of fruit development.

In all years if response was obtained to nitrogen application, it was at the later harvest dates. This was related to the effect of nitrogen on stimulation of early vegetative growth which allowed increased branching and established a nutritive condition that supported an extended period of fruit set.

Summary

The response of tomatoes to nitrogen fertilization was tested in the field on soils typical of those used on commercial tomato production over a period of years from 1957 to 1961. In 1957, 40 pounds of nitrogen significantly increased the yield of tomatoes grown on a Miami silt loam following a grass sod. In 1958, the Epoch variety tomatoes, a dwarf variety, did not respond to nitrogen applications. In 1960 Tecumseh variety tomatoes responded to 125 pounds of N with no further effect at 525 pounds per acre of nitrogen. In 1961, an extremely dry season during the period of fruit development, no yield response was obtained to the nitrogen applications between 0 and 300 pounds per acre. Four hundred pounds per acre resulted in a decrease in yield due to a high incidence of blossom end rot. As the nitrogen rate was increased between

0 to 125 pounds, vine growth was increased and at the 125 pound rate visible deficiency symptoms under heavy fruit load failed to develop, whereas, visible deficiency symptoms would develop below 100 pounds N per acre under heavy fruit load.

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The Relation of pH to Available Phosphate and Potash in Purdue Soil Tests, 1961[1]

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Soil test summaries reported by Barber and Bronson (1) and by Jones, Mederski, and Musgrave (2) failed to show any relationship between soil pH and available phosphate in older Indiana and Ohio data. Neither did these summaries show the relationship between soil pH values and soil tests for potash. As a result of this information and because of secondary objectives, the relations between soil pH and available phosphate and available potash in the 1961 Purdue soil tests were the major objective of this investigation.

Another objective of this investigation was to compare soil pH, available phosphate, and available potash tests in the 1961 data, with the summary of 65,483 samples analyzed in the 1952-1954 data reported by Barber and Bronson. (1) Another secondary objective was to find where in the distribution of phosphate tests tabulated in relation to soil pH, that tests were unusually high where rock phosphate might have influenced the results.

Methods and Procedures

This investigation consisted of summarizing data from about half of the total of 50,551 soil samples tested during 1961 at the Purdue Soil Testing Laboratory. For the phosphate versus pH study there were 8 classes of phosphate on the horizontal axis and 7 pH classes on the vertical axis. All combinations of pH and phosphate classes resulted in 56 separate categories. Likewise, in the potash versus pH study there were 8 potash classes and 7 pH classes resulting again in 56 separate categories. A total of 22,280 samples was summarized in each of the two studies. All samples were not the same in the two studies because two different people working at different times made the summaries.

Statistical analyses consisted of averages and calculation of percentages.

Results and Discussion

The distribution of soil pH values for the 1952-1954 data as reported by Barber and Bronson (1) is compared in Table 1 with that for 1961. There were 23.9 percent of the 1952-1954 soil samples that tested above pH 6.5. In the 1961 data there were 38.78 precent of the samples in the phosphate versus pH study and 38.19 percent in the potash versus pH study that tested above pH 6.5. Values in the phosphate study were not significantly different at 95 to 5 odds from those in the potash study. Since soils above pH 6.5 were not considered as needing lime these data indicate that fewer of the samples tested in 1961 needed lime than those tested in 1952-1954. Possible explana-

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[1] Journal Paper No. *2022* Purdue University Agricultural Experiment Station. Contribution from the Department of Agronomy.

TABLE 1. Distribution of soil pH values in three different studies, Purdue Soil Testing Laboratory.

Soil pH	1952-1954 Percent	1961 Phosphate Study Percent	1961 Potash Study Percent
Less than 5.1	1.9	1.06	1.08
5.1—6.5	74.4	60.13	60.73
More than 6.5	23.9	38.78	38.19

tions for this difference may be that farmers testing in 1961 were liming their soils to a higher pH than those testing in 1952-1954, the samples tested in 1961 were from a different population of soils or fields than those tested in 1952-1954, or the farmers who tested in 1952-1954 had applied lime resulting in a higher pH in 1961.

A comparison of phosphate soil tests for 1952-1954 with those of 1961 is shown in Table 2. The very high class contained slightly the largest percentage of all samples in both periods. There were no indications of important differences between the data for the two periods.

TABLE 2. Distribution of phosphate soil tests, 1952-1954 and 1961, Purdue Soil Testing Laboratory.

Phosphate Classes, Lbs. per A.	1952-1954 Percent	1961 Percent
0—40 (Very Low)	16.9	15.7
41—100 (Low)	22.7	23.3
101—180 (Medium)	21.2	19.2
181—300 (High)	16.4	17.6
300+ (Very High)	23.0	24.2

The comparison of potash tests for 1952-1954 with those of 1961 is given in Table 3. There were real differences between the medium

TABLE 3. Distribution of potash soil tests, 1952-1954 and 1961, Purdue Soil Testing Laboratory.

Potash Classes, Lbs. per A.	1952-1954 Percent	1961 Percent
0—100 (Very Low)	15.7	12.5
101—180 (Low)	58.2	56.0
181—250 (Medium)	5.8	19.6
251—375 (High)	17.0	8.8
376+ (Very High)	3.7	3.2

and high classes. The percent in the medium class for the 1961 data was 19.6 as compared to 5.8 percent in the 1952-1954 data. In the high class a reverse relationship was found with 8.8 percent in 1961 compared with 17.0 percent in 1952-1954. One possible explanation for this difference may be that farmers were cropping heavier in 1961 than in 1952-1954, and as a result, they were taking out more potash in 1961 compared with the previous period. Another possible explanation may be as stated previously, that a different population of soils was being sampled in 1961 as compared to those sampled in 1952-1954.

The relation of soil pH to available phosphate in the 1961 data is shown in Table 4. The largest single value, 8.20 percent, was in the low phosphate class within the pH range of 6.1-6.5 inclusive. The largest pH class was 6.1-6.5 inclusive with 35.39 percent of the total. In the very low, low, medium, and high phosphate classes, the great majority of samples fell in the pH range 5.1 to 7.5 inclusive. If one considers any value with 1.0 percent or more as being important in the very high phosphate classes, the important values were from pH 5.6 to 7.5 inclusive at the low end and from 6.6 to 7.0 inclusive at the high end or in the 901+ class. The values became less from low to high in the very high phosphate classes, so that in the 701-900 phosphate class there were no values as great as 1.0 percent. In the 901+ phosphate class at pH 6.6-7.0 inclusive there was one important value, 1.27 percent. One might suspect that rock phosphate applications to the soil had influenced the tests included in the 1.27 percent value. Regardless of the reason for this small island of high tests, there was evidence of buildup or an increase in the values in the 901+ phosphate class.

The relation between soil pH and available potash is given in Table 5. This distribution was similar to that for phosphate except for certain major differences. These differences were primarily in the very high potash classes. There were no single values with more than 1.0 percent in the very high potash classes. There was no definite indication of a large decline in percentages from the low to the high values among the very high potash classes. The values in the 976+ class of very high potash were, in the main, smaller than other very high potash classes. This indicates that there was no buildup of soil potash like there was for phosphate.

Summary

Soil pH, phosphate, and potash data from 22,280 soil samples tested in the Purdue Soil Testing Laboratory in 1961 were summarized and compared with a summary of 1952-1954 data from the same laboratory. Samples testing above pH 6.5 increased from 23.9 percent in the 1952-1954 period to approximately 38.5 percent in the 1961 period. A comparison of the phosphate tests from the same two periods showed no real differences. However, the potash tests were different. The percent of samples in the medium potash class in the 1961 summary was 19.6 as compared to 5.8 percent in the 1952-1954 data. There was a reduction in the high potash class in the 1961

TABLE 4. Relation of soil pH to available phosphate in 22,280 soil samples, 1961, Purdue University Soil Testing Laboratory.

Classes of Soil pH	Classes of Available Phosphate (P_2O_5) in Lbs. per A.								Total
	Very Low	Low	Med	High	Very High				
	0.40	41-100	101-180	181-300	301-500	501-700	701-900	901+	
					Percent of Samples				
7.6+	0.11	0.17	0.15	0.16	0.35	0.22	0.08	0.34	1.58
7.1-7.5	1.20	2.09	1.52	1.54	1.31	0.38	0.29	0.94	9.27
6.6-7.0	3.38	6.97	5.25	4.88	3.97	1.55	0.66	1.27	27.93
6.1-6.5	4.49	8.20	7.15	6.80	5.03	1.93	0.92	0.87	35.39
5.6-6.0	3.93	4.20	3.74	2.94	1.91	0.62	0.20	0.32	17.86
5.1-5.5	2.30	1.48	1.16	1.10	0.54	0.15	0.07	0.08	6.88
Less Than 5.1	0.27	0.16	0.18	0.21	0.14	0.04	0.02	0.04	1.06
Total	15.68	23.27	19.15	17.63	13.25	4.89	2.24	3.86	99.97

TABLE 5. Relation of soil pH to available potash in 22,280 soil samples, 1961, Purdue University Soil Testing Laboratory.

	Classes of Available Potash (K_2O) in Lbs. Per A.								
Classes of Soil pH	Very Low	Low	Med	High	Very High				
	0-100	101-180	181-250	251-375	376-575	576-775	776-975	976+	Total
	Percent of Samples								
7.6+	0.17	0.67	0.26	0.19	0.01	0.04	0.04	0.07	1.45
7.1-7.5	1.18	4.73	1.41	0.78	0.11	0.22	0.13	0.10	8.66
6.6-7.0	3.34	15.67	5.49	2.59	0.25	0.38	0.19	0.16	28.07
6.1-6.5	4.20	21.00	7.60	3.19	0.26	0.33	0.17	0.13	36.88
5.6-6.0	2.33	9.74	3.41	1.45	0.11	0.13	0.04	0.04	17.25
5.1-5.5	1.04	3.67	1.23	0.51	0.07	0.08	0.02	0.00	6.62
Less Than 5.1	0.24	0.56	0.15	0.06	0.02	0.04	0.01	0.00	1.08
Total	12.50	56.04	19.55	8.77	0.83	1.22	0.60	0.50	100.01

summary compared with the earlier period. Possible explanations for these differences were given.

In the phosphate versus pH and in the potash versus pH studies of the 1961 data the highest percentages of samples were in the low and medium classes at soil pH's of 6.1 to 7.0 inclusive. A breakdown of the very high phosphate data showed that there was no well defined place at which numbers of samples rapidly declined. There seemed to be a slight increase or buildup at the top or 901+ class in very high phosphate. However, in the potash versus pH study there was a well defined place at which numbers of samples rapidly declined. This was between the high and the very high classes. There was no increase in percent of samples at the top of the very high potash classes.

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The Micronutrient Status of Soybeans in Indiana as Determined by Foliar Analysis[1]

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Introduction

Foliar analysis as a means of determining the nutritional well being of a crop, is a well established procedure for selected crops in several countries. The micronutrient status of soybeans in Indiana appears likewise to be capable of definition by analysis of leaf samples collected in a recent survey. The plant status in turn reflects the micronutrient supplying power of the soils on which the plants were grown. Data from a recent survey are herein reported.

Experimental Procedure

In August of 1957, 64 soybean fields were sampled in an area approximately 50 miles wide extending from Walkerton to Evansville, Indiana. The plant samples consisted of leaflets and petioles from the 3rd, 4th and 5th nodes from the stem apex. Approximately 40 plants were sampled in each field at a distance of about 100 feet from the highway right-of-way. Soil samples were taken at most of the sample sites. The plant samples were oven-dried at 170°F., and ground in a Wiley mill equipped with a chromium plated screen. Portions of the sample were forwarded to the University of Illinois Agronomy Department for spectrographic analyses for 11 mineral elements. Molybdenum analyses were by courtesy of Dr. S. A. Barber of the Purdue University Agronomy Department. The results of the spectrographic analyses were tabulated and reported for the 6 micronutrient elements; iron, copper, zinc, maganese, boron, and molybdenum. Growth and sampling information were obtained by the courtesy of Athow and Probst (1). Due

TABLE 1. Optimal and Threshold Concentrations of Micronutrients in Soybean Leaves.

Micronutrient	Deficiency Threshold, ppm	Optimal Range, ppm
Molybdenum	?	0.5-1.0 ?
Copper	10 ?	10-20
Manganese	20	40-200
Boron	16	20-100
Zinc	15	15-30
Iron	?[1]	?[1]

[1] Total iron is not a reliable index of sufficiency.

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TABLE 2. Micronutrient composition of soybean leaflet and petioles as influenced by soil region and sub-class.

Soil Region	Sub-class		No. of Samples	Parts per Million					
				B	Mn	Fe	Cu	Zn	Mo
A	Level, well-drained	range		37-53	41-93	79-98	6-11	15-74	.38-1.32
		ave.	4	49	69	86	9	44	.96
A	Level, poorly-drained	range		30-74	4-60	63-192	6-20	36-56	.15-2.65
		ave.	13	50	23	133	13	42	.92
C	Level soils	range		35-77	13-86	56-397	9-21	28-45	.40-2.32
		ave.	5	46	39	171	13	35	1.23
D		range		50-85	22-55	56-220	13-17	42-51	.48-1.70
		ave.	3	73	42	131	15	47	.54
E	Level, light colored	range		54-70	13-151	125-620	12-17	47-59	.58-1.60
		ave.	4	64	89	353	15	52	.72
E	Sloping, light colored	range		50-76	16-127	81-262	13-23	42-60	.48-1.85
		ave.	4	66	81	147	18	49	.88
E	Dark colored	range		48-66	10-23	85-97	15-20	43-49	.38-1.08
		ave.	3	55	18	89	18	46	.79

G		range		30-71	4-95	52-900	14-19	32-49	0.2-5.1
		ave.	4	48	37	310	16	38	1.47
H	Loams and heavier textures	range		45-118	32-217	149-385	12-26	36-75	.12-.52
		ave.	6	73	99	228	18	52	.4
I	Level	range		32-33	51-86	97-270	10-12	10-57	.25-.42
		ave.	3	33	73	165	11	39	.34
I	Sloping	range		48-69	35-142	160-1000	16-17	48-60	0.3-0.9
		ave.	2	59	89	580	17	54	0.6
N		range		48-48	12-33	128-435	17-19	37-37	.72-.92
		ave.	2	48	23	282	18	37	.82
O		range		25-71	12-256	66-820	9-20	32-90	.35-.65
		ave.	5	44	101	314	13	49	.43
P		range		35-61	19-77	60-470	12-18	28-72	.35-1.1
		ave.	6	50	42	194	15	45	.67
	TOTAL	RANGE		25-118	4-256	52-1000	6-26	10-90	.12-5.1
		AVERAGE		54	56	208	15	44	.99

to the nature of the survey, perfect replications of variables were not obtained. Although these data have certain limitations with regard to replication, these results were considered to be useful in evaluating micronutrient supplying power of the various soils regions.

Results and Discussion

The agronomic information collected with each sample is not reported in this paper. It is available in progress reports (7) and should be used in evaluating the full significance of any sample data.

Table 1 contains the concentrations of micronutrients tentatively considered optimal for adequate mineral nutrition of soybeans. The values are those suggested by Ohlrogge (5) after a survey of the literature.

It is recognized that the optimal concentration of nutrients will vary with physiological age and growth conditions. However, this table serves as a first approximation of the standard for comparison needed to evaluate the results of this survey.

Table 2 is a compilation of the ranges and averages observed for each micronutrient in plant samples taken from various soils regions. The soils regions are similar to those used by Barber and Bronson (2). Caution must be used in interpreting differences in elemental composition found in this survey due to the broadness of the soil classification, lack of background information concerning cultural practices used in the fields sampled, and the number of other variables in this survey. However, since the samples were more or less randomly selected, they should indicate possibly deficient or potentially deficient

TABLE 3. Influence of variety and physiological age on micronutrient content of soybean leaves.

	Concentration (ppm) of micronutrient				
Variety	Clark		Hawkeye		Harosoy
Stage of Development	6	8-9	6	8-9	6
Number of Samples	3	7	8	7	8
Micronutrient					
Boron, range	44-93	25-71	37-76	32-58	39-85
ave.	69	50	61	41	41
Manganese, range	33-217	33-256	23-151	13-86	15-60
ave.	98	104	86	45	34
Iron, range	165-330	128-820	85-560	57-270	56-397
ave.	225	382	184	239	175
Copper, range	15-26	12-20	6-23	10-14	13-21
ave.	20	15	15	12	16
Zinc, range	51-52	37-90	13-74	10-51	36-51
ave.	52	60	48	36	44
Molybdenum, range	0.12-0.52	0.30-1.0	0.38-1.85	0.25-5.10	0.15-2.65
ave.	0.35	0.58	0.95	1.14	1.10

soils regions or areas. This assumes slight or negligible differences due to variety or state of development.

The level, well-drained soils of region A, and certain of the level, poorly drained soils of region I, appear to produce plants containing less copper than do other soils regions. This does not appear to be simply a soil pH effect on availability of copper because the four soil samples from the well-drained soils from region A have an average pH of 6.2 (range 5.9-6.4) whereas three soil samples from region G also have an average pH of 6.2 (range 6.0-6.6). These data indicate the fruitfulness of future expanded surveys of this kind in identifying soils which may be deficient or potentially deficient in certain micronutrients.

Table 3 is a compilation of micronutrient composition ranges and averages for three varieties of soybeans (Clark, Hawkeye, and Harosoy), at development stage 6 and the former two varieties at stages 8 and 9. These stages are defined by Weber of Iowa. The data indicate that the Clark variety may have the ability to absorb more manganese than does Hawkeye. The effect is indicated at both stages of development, but is more striking at the later stage of development.

Added significance must be given to the manganese difference when the other nutrients are studied. Although the differences in the averages for the other nutrients are small, they are amazingly consistent.

TABLE 4. A comparison of Mn, B, Cu and Mo content obtained in survey to values previously obtained from plants grown on similar soils.

Soil Type	No. of Samples	Range	Ave.	No. of Samples	Range	Ave.
	Volk's Samples			Wilkinson's Samples		
		MANGANESE (ppm)				
Maumee	3	23-99	26	5	5-15	9
Plainfield	2	170-220	195	2	70-70	70
Crosby	3	41-56	47	6	13-151	72
Miami	3	16-88	51	3	44-120	84
Brookston	3	12-32	21	6	4-55	21
		BORON (ppm)				
Maumee	3	19-38	27	5	30-50	41
Plainfield	2	25-30	28	2	37-52	45
Crosby	3	30-35	33	6	39-70	58
Miami	3	29-51	38	3	50-72	62
Brookston	3	34-36	35	6	30-85	54
		COPPER (ppm)				
Maumee	4	9.9-24.7	14	5	9.0-17.4	13
Plainfield	2	6.8- 8.5	8	2	5.9- 9.1	8
Crosby	3	12.7-18.7	15	6	12.1-16.5	14
Miami	3	9.5-14.6	13	3	13.4-17.5	16
Brookston	3	13.0-21.0	16	6	13.6-20.3	16
		MOLYBDENUM (ppm)				
Maumee	4	0.00- .45	0.14	5	.52-2.02	0.97
Plainfield	2	.18-3.54	1.85	2	.38-1.32	0.85
Crosby	3	.19- .45	0.34	5	.48-1.60	0.94
Miami	3	.01- .93	0.52	3	.48- .68	0.56
Brookston	3	.22- .67	0.42	6	.1 -1.08	0.54

Fields sampled in the later maturity group are completely different from those in the earlier group. A study of the soil types associated with each sample indicates there is little or no confounding of variety effect by the soil type effects.

Table 4 contains the results of analyses of soybean plants by Knudsen (3) and Volk (6) compared to the results obtained in this survey of samples from the same or similar soil types. Knudsen's and Volk's results are by wet chemical procedures on whole plant samples.

In general, the boron and molybdenum concentrations found by Volk are lower than the recent leafs sample analyses. Copper concentrations show amazingly good agreement. The manganese results are variable and zinc values are not included, because the Volk samples were contaminated with zinc during processing. Both surveys however, clearly classify the same soils into the high and low groups which gives convincing evidence of the usefulness of foliar analysis. It is well known that the Maumee and Brookston soils are potentially manganese deficient and these analyses indicate such. Recent experiments on the Plainfield sand have given significant responses to copper, which also would be predicted by these data.

Summary

Sixty-four soybean leaf samples were collected in a survey of soybean fields in eastern Indiana in 1957. These samples were spectrographically analyzed for their micronutrient contents. Data from an earlier survey were compared to these later results.

Variety difference in manganese contents is indicated. Foliar analysis appears to give a good indication of the nutrient supplying power of the soil. Both surveys ranked five soil types in the same approximate order. The greatest and least precision in the comparison was for copper and molybdenum, respectively.

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The Erodibility of Some Indiana Soils[1]

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Knowledge of the relative erodibility of soils is essential to sound planning of conservation and management programs. A new procedure for predicting soil losses from cropped land is now being introduced into the Cornbelt (7). This procedure utilizes an absolute soil erodibility factor with continuous cultivated fallow as base. Measurements of soil losses from fallow are necessary to obtain an accurate value of the erodibility factor of the various soils. Soil losses were measured with the ARS-Purdue rainulator. This paper presents the methods and results of such measurements on 15 locations within the State of Indiana.

Several laboratory procedures for measuring soil characteristics considered indicative of the soil's erodibility have been proposed in the literature (1, 2). Many of these characteristics are being measured as a part of this study in conjunction with the actual soil loss measurements. When a large volume of the information has been gathered, quantitative prediction of erodibility based on these concomitant measurements may be possible.

Procedure

Fifteen pairs of plots were located on various soil types with the help of Soil Conservation Service personnel in the spring of 1961. Plots were selected to obtain a range of soils differing in texture and parent material combined with a narrow range of slope.

Whenever possible, sites were selected which had been in row crops during the two years preceding the test to reduce variability due to past cropping history. These plots were plowed in the spring and kept fallow by disking until July or August.

Prior to plowing, all existing vegetation and residues were removed and the plots were disked twice to smooth the surface. Plowing was up and down slope to a depth of about seven inches. All locations were disked five times after plowing and prior to making the tests with the rainulator—once shortly after plowing, twice approximately one month after plowing and two more times just prior to the rainulator runs. The final disking in all cases was up and down slope. A small farm tractor with three-point hitch equipment was used for tillage operations.

Locations, soil type, percent slope, cropping history, date of plowing and dates of rainulator runs are presented in table 1. Cropping history is given for the years 1959, 1960 and 1961. Since all locations were plowed in the spring, little effect on soil erodibility would be expected from the 1961 crop. The Fox and Parr silt loams located in Fountain County

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[1] Contribution from the Soil and Water Conservation Research Division, Agricultural Research Service, U.S.D.A., in cooperation with the Purdue Agricultural Experiment Station. Purdue Journal Series Paper No. 1995.

TABLE 1. Locations and descriptions of plots from which soil loss and runoff measurements were taken.

Location	Soil Type	% Slope	Crop Hist.[1]	Date Plow[2]	Date Run[3]
Fountain Co., Sec. 14, T21N, R7W	Fox silt loam	8.63	CBW$_m$	5-17	8-7
Fountain Co., Sec. 9, T20N, R6W	Manlove silt loam	7.23	BW$_m$M	5-16	8-15
Fountain Co., Sec. 1, T21N, R6W	Manlove silt loam	4.60	MFF	5-5	10-7
Fountain Co., Sec. 28, T21N, R6W	Parr loam	7.20	CBW$_m$	5-16	8-10
Kosciusko Co., Sec. 21, T32N, R7E	Miami sandy loam	7.84	CCC	5-23	7-19
Kosciusko Co., Sec. 11, T30N, R6E	Morley loam	10.52	CCC	5-22	7-19
Kosciusko Co., Sec. 34, T31N, R5E	Celina loam	8.24	CCC	5-22	7-26
Kosciusko Co., Sec. 34, T31N, R5E	Celina sandy loam	8.50	CCC	5-22	7-26
Orange Co., Sec. 6, T2N, R2E	Bedford silt loam	6.72	CCC	5-25	9-6
Orange Co., Sec. 10, T1S, R1E	Elkinsville silt loam	7.82	CC$_g$C	5-24	8-31
Orange Co., Sec. 2, T1S, R1E	Zanesville silt loam	8.38	MCO$_m$	5-25	8-31
Tippecanoe Co., Sec. 30, T24N, R4W	Miami loam	9.48	CCC	5-18	8-22
Tippecanoe Co., Sec. 20, T24N, R4W	Celina loam	9.09	BW$_m$M	5-19	8-22
Tippecanoe Co., Purdue Throckmorton Farm	Wea silt loam	5.58	CCO$_m$	5-18	8-2
Washington Co., Sec. 27, T2N, R4E	Bewleyville silt loam	14.54	CO$_m$M	5-24	9-6

[1] Denotes cropping history—1959, 1960 and 1961. C—corn, B—soybeans, W$_m$—wheat with meadow intercrop, M—meadow, O$_m$—oats with meadow intercrop, F—fallow, Cg—corn with winter cover of rye grass that was heavily pastured in 1960. Essentially no cover remained in the spring of 1961.

[2] Dates given are month and day plots were plowed

[3] Dates given are month and day rainulator runs were conducted.

which were in winter wheat were the only ones that had a significant amount of growth at time of plowing.

Each set of plots was treated and measured as follows. Each plot was covered with black plastic between the time of the last disking and the time of the run. This was to insure that a freshly tilled surface was exposed to the initial rainulator run and that the soils tested were at a moisture content at or below field capacity. Gravimetric moisture determinations were made from the upper 12 inches to further investigate moisture as a variable between locations. The rainulator was assembled over the adjacent plots, each 12 feet by 35 feet, as shown in figure 1.

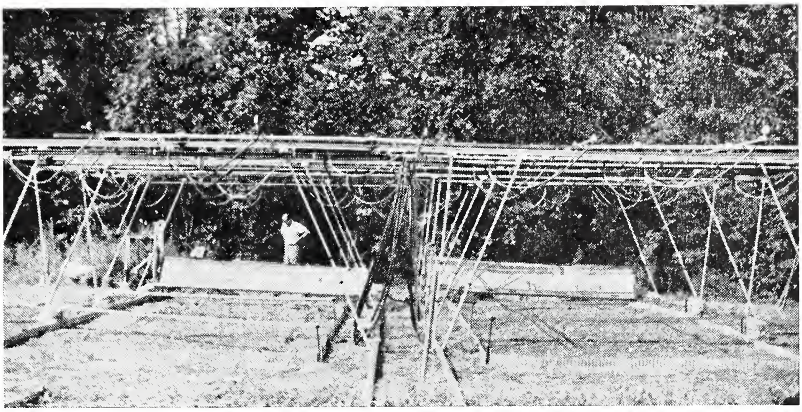

Figure 1. Rainulator assembled over two plots.

The plots were subjected to a total of 5 inches of artificial rainfall at an approximate intensity of 2.5 inches per hour applied in three separate storms. The three storms consisted of an initial run of 60 minutes' duration, a wet run of 30 minutes' duration approximately 24 hours later, and a very wet run of 30 minutes' duration starting 15 minutes after the cessation of the wet run.

The rate of runoff was measured continuously with a calibrated flume and an FW-1 waterstage recorder. Aliquot samples of the runoff were taken throughout the run, and the amount of soil in the runoff water was determined. The soil loss for the time of sampling was then taken as the product of the percent soil in the sample and the total runoff for the sampling period.

Complete profile descriptions of the soil at each location were made by Soil Conservation Service soil scientists. These descriptions, along with the test results, may provide another means for evaluation of test results with variations in soils.

Soil samples to a depth of 6 inches were taken just prior to the run. These samples were used to determine such things as the particle size distribution, organic matter content and aggregate stability of the soil. At 10-minute intervals during the run, small portions of the plots were covered, and the top centimeter of soil under these covers was used to determine the suspension percentage and dispersion ratio of the soils. The latter offers indirect measurement of soil structure.

Results

A summation of the rainfall application, infiltration, runoff, percent soil in runoff and soil loss for the three runs by location is given in table 2. The soil-loss data in this table have not been adjusted for differences in slope and cropping history. The apparent lack of correlation between runoff and soil loss is accounted for by differences in the amount of soil carried by the runoff water as indicated by percent soil in runoff. The differences among soils are reflected by both amount of runoff and amount of soil suspended in the runoff.

TABLE 2. Summary of results by soil type. Data presented are results from a total of 5 inches of rainfall applied at an intensity of 2.5 inches/hour.

Soil Type	Infiltration	Runoff	Soil Content of Runoff	Soil Loss
	in.	*in.*	*percent*	*tons/acre*
Fox si. l.	2.56	2.44	6.44	17.80
Manlove si. l.	2.73	2.27	6.29	16.17
Manlove si. l.	1.79	3.21	3.31	12.03
Parr l.	2.38	2.62	4.07	12.07
Miami s. l.	2.17	2.83	3.45	11.07
Morley l.	2.17	2.83	5.08	16.22
Celina s. l.	2.24	2.76	4.71	14.73
Celina l.	1.84	3.16	5.36	19.21
Bedford si. l.	2.14	2.86	7.56	24.49
Elkinsville si. l.	1.85	3.15	5.94	21.20
Zanesville si. l.	2.35	2.65	4.59	13.77
Miami l.	2.34	2.66	5.28	15.98
Celina l.	1.98	3.02	5.76	19.69
Wea si. l.	2.80	2.20	3.64	9.07
Bewleyville si. l.	1.71	3.29	7.62	28.41

The total soil loss from the various soil types adjusted to account for differences in slope and cropping history is given in table 3. The adjusted soil losses were obtained by using adjustment factors previously published (5, 6). The adjusted soil losses are what would be expected from each soil if it were in continuous fallow on a 9 percent slope, 72.6 feet long. This is the base plot used in the soil loss prediction equation now being adopted for use in the Cornbelt (7). Two separate adjustment factors were therefore involved in these adjustments—one for length and degree of slope and one for prior cropping practices.

In the soil-loss prediction equation, the rainfall factor is given as an index determined from the characteristics of the rainfall. The erosion index (4) for the 5 inches of rainfall applied equals 100. The erodibility factor, i.e. the amount of soil loss per unit of the erosion index from a base plot, can be obtained by dividing each adjusted soil loss by 100. These values are shown in the last column of table 3 and

TABLE 3. Actual and adjusted soil loss and estimated "K" factors obtained from rainulator runs.

Soil Type	Soil Loss			"K" factor
	Actual	Adjusted for Slope	Adjusted for Slope & Crop	
	tons/acre	*tons/acre*	*tons/acre*	
Fox si. l.	17.80	27.81	32.72	.33
Manlove si. l.	16.17	32.34	46.20	.46
Manlove si. l.	12.03	44.56	44.56	.45
Parr l.	12.07	24.14	28.40	.28
Miami s. l.	11.07	19.72	23.20	.23
Morley l.	16.22	19.08	22.45	.22
Celina s. l.	14.73	24.14	28.40	.28
Celina l.	19.21	31.49	37.05	.37
Bedford si. l.	24.49	56.95	67.00	.67
Elkinsville si. l.	21.20	40.77	47.96	.48
Zanesville si. l.	13.77	22.57	30.09	.30
Miami l.	15.98	22.81	26.84	.27
Celina l.	19.69	28.54	40.77	.41
Wea si. l.	9.07	26.58	31.27	.31
Bewleyville si. l.	28.41	19.60	28.00	.28

indicate the relative erodibilities of the various soils tested. These relationships are subject to change as the adjustment factors become more refined.

The success in predicting relative soil loss from other than direct measurements has not yet been established. One of the most promising of the laboratory measurements mentioned in the procedure has been the suspension percentage. This is a measure of the amount of soil existing in particles of <20 microns in size after being subjected to agitation in water. This procedure is a modification of the one given by Middleton et al. (1). The coefficient of determination (R^2) between the soil loss as the dependent variable and slope and suspension percent as the independent variables was .68. This was highly significant. More data are needed to test this and the other laboratory measurements procedure more fully.

Discussion

The results reported here are the first year results of a study in progress. These results, although preliminary, show that Indiana soils do vary with respect to inherent erodibilities. Through the direct approach of evaluating the various soils under similar rainfall patterns, it is hoped that "K" values for use in the soil loss prediction equation can be obtained which will better characterize these soils. The direct results given in table 3 correspond in magnitude with similar results obtained from runoff plots under natural rainfall and reported elsewhere

(3). The data are still too limited to fully explore the possibility of using laboratory measurements to predict soil loss from fallow.

The laboratory measurements conducted in this study should, however, be an aid in determining the erodibility factors of Indiana soils. It is essential that quantitative evaluations of soil erodibility be made, if the methods of predicting erosion losses are to be refined. The direct method employed in this study is too time consuming and costly to be used to evaluate each soil type and variation in soil type. A faster, less expensive method must be found.

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Natural and Fission-produced Radioactivity in Four Indiana Soils[1]

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Continued testing of nuclear weapons and increasing developments in reactors for use in power production have caused growing concern about the levels of fission-produced radioactivity in the earth's surface. In order to establish reference points for the levels of natural and fission-produced radioactivity in Indiana, bulk samples of the 0-6" layer of four well-characterized soils were collected for determination of gamma ray activities. Periodic checking of samples from these sites will provide information on the build-up of radioactivity.

Introduction

Naturally occurring radioisotopes in soils include the thorium and uranium series and K^{40}. The amounts of these isotopes depend on materials from which the soils are developed and the extent of weathering and leaching.

The gamma-ray spectra emitted by present-day surface soils reveal the presence of several lines which do not pertain to the thorium and uranium series or to K^{40}. These additional gamma-ray lines come from radioactive fission products in fall-out (2).

Fission-produced radioisotopes in fall-out include Zr^{95}-Nb^{95}, Sr^{90}, Rh^{106}-Ru^{106}, I^{131}, Cs^{137}, Ba^{140}-La^{140}, and Ce^{144}-Pr^{144}. Of these, Cs^{137} and Sr^{90} are of greatest concern because of their relatively long half-lives and their entrance into the food chain. Since the behavior of Cs^{137} and Sr^{90} in soils and plants is somewhat similar to that of K and Ca, respectively, it is of considerable concern to be able to detect and measure these radioisotopes.

In natural environments, radioactive fission products can get into plants both through the aboveground portions of the plant from external surface contamination (direct absorption) and through the roots by uptake from the contaminated soil.

Sr^{90} has probably received the greatest attention because of its accumulation in the bones of the human body. Kulp and Schulert (3) have made detailed studies of Sr^{90} in man and as a result have developed an equation which makes it possible to predict the average number of micromicrocuries of Sr^{90} per gram of calcium in milk when data on rate of fallout in rain and cumulative deposition in soils are available.

Thus, measurements of the cumulative deposition of fission-produced radioisotopes in soils and the amount of fallout in precipitation become very important in making predictions of levels of Sr^{90} in the milk supply as well as in assessing other possible harmful radiation effects.

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The measurement of naturally occurring and fission-produced radioisotopes generally requires cumbersome radiochemical separation procedures. Gustafson et al. (2) and Mortensen (6) have recently applied scintillation spectrometry for the detection and measurement of gamma emitters in soils and plants. Gustafson (1) has particularly emphasized the desirability of using Cs^{137} as a monitor for Sr^{90} in soils.

Since Cs^{137} is a gamma-emitter it can be measured by gamma-ray spectrometry. Sr^{90}, on the other hand, is a beta-emitter and its direct determination requires time-consuming and costly chemical separation processes.

During the fission process, approximately 1.76 atoms of Cs^{137} are formed for each atom of Sr^{90}. When the half-lives of these two are considered, the Cs^{137}/Sr^{90} activity ratio is found to be 1.83. This ratio should be universally prevalent in fallout if no fractionation occurs from the time of detonation to the time of deposition on the ground (1).

After the radioisotopes are deposited on the soil surface fractionation is quite likely to occur with Cs^{137} being more strongly retained than Sr^{90}. If the soil is sampled to a depth of 6 inches, virtually all radioactive fission products should be included and the Cs^{137}/Sr^{90} ratio should be fairly constant.

Gustafson (1) examined the Cs^{137}/Sr^{90} ratio data for numerous samples of rain water and surface soils. He found the ratio in the upper 2 inches of the soils to vary from 1.3 to 1.8 and concluded that the Sr^{90} concentration could be estimated within ± 20 percent by measuring the Cs^{137} and dividing by 1.6.

Experimental Procedure

Bulk soil samples of 80-100 lbs. were taken from the 0-6″ layer of adjacent virgin and cultivated sites. The locations and sampling dates are given in Table 1. The samples were air-dried, crushed and passed through a 2 mm. sieve.

TABLE 1. Location of Sample Site and Sampling Date.

Plainfield sand—Porter County, E ½ NE ¼ NE ¼ Section 12, T 37 N, R 5 W. Sampled May 3, 1961.
Crosby silt loam—Hancock County, NW ¼ NE ¼ Section 20, T 16 N, R 7 E. Sampled May 17, 1961.
Clermont silt loam—Franklin County, SW ¼ Section 32, T 8 N, R 2 W. Sampled May 17, 1961.
Zanesville silt loam—Dubois County, S ¼ SW ¼ SE ¼ Section 21, T 3 S, R 5 W. Sampled May 16, 1961.

The gamma-ray spectra were taken with a scintillation counter which consisted of 5 x 4-inch NaI(Tl) crystal mounted on a DuMont 6364 photomultiplier tube enclosed in stainless steel. A 2 kg. soil sample was placed in a special stainless steel container which allowed a sample thickness of 1 inch to be distributed around and over the scintillation crystal. Background was reduced by the use of thick steel shielding around the sample and detector. Pulse-height analysis was carried out with an Argonne type 256 channel analyzer.

The concentration of fission and natural radioactivity in the soil samples was determined by using sources of known activity incorporated in a mock soil consisting of Na_3PO_4.

In preliminary measurements the activities of the virgin and cultivated samples from a given site were found to be essentially the same. The measurements reported are the average for the pair. Activities were corrected for decay to sampling date.

Gustafson et al. (2) showed that 97 percent of fission activity in soil occurred at a depth of 0-3″. The use of samples from 0-6″ depth should thus insure sampling of all fission activity that had accumulated up to the time of sampling.

Results and Discussion

The levels of naturally occurring gamma-ray activity are shown in Table 2. The values agree well with those given by Gustafson et al. (2) and Mortensen (6). It is perhaps significant that the Clermont soil is one of the older soils in the state and its content of U+ and Th+ is the highest of the four soils examined.

TABLE 2. Naturally Occurring Gamma-ray Activity in Four Indiana Soils (0 - 6 Inches).

Soil	U+	Th+	K^{40}
	x 10^{-3}g./kg.	x 10^{-3}g./kg.	g./kg.
Plainfield s	0.76	1.74	15.1
Clermont sil	3.95	9.36	14.2
Crosby sil	3.05	7.76	12.3
Zanesville sil	3.17	6.14	14.1

The levels of fission-produced gamma-ray activity are shown in Table 3. The Plainfield soil has the lowest levels of the four soils; this suggests the possibility that some loss by leaching may occur on this very porous soil. The values are in good agreement with those of Gustafson et al. (2).

TABLE 3. Fission-produced Gamma-ray Activity and Estimated Sr^{90} Content in Four Indiana Soils (0-6 Inches).

Soil	Cs^{137}	Ru^{106}-Rh^{106}	Ce^{144}-Pr^{144}	Estimated Sr^{90}[1]
		millicuries per square mile		
Plainfield s	35	76	65	22
Clermont sil	50	108	170	31
Crosby sil	58	150	170	36
Zanesville sil	43	157	177	27

1. Estimated by dividing the Cs^{137} activity by 1.6 (Gustafson. Sci. 130:1404-1405, 1959).

The last column gives the estimated concentration of Sr^{90} using the activity ratio Cs^{137}/Sr^{90} of 1.6 as suggested by Gustafson (1). This is also in good agreement with prevailing Sr^{90} values for this geographic area.

The equation for predicting Sr^{90} content of milk as given by Kulp and Schulert (3) is as follows:

$$Q_m = AX + BY$$

where Q_m is the average number of micromicrocuries of Sr^{90} per gram of calcium in milk; X is the average rate of deposition of Sr^{90} in mc./mi.^{2} per 6 months for a particular growing season; Y is the cumulative deposit of Sr^{90} in mc./mi.^{2} measured at the midpoint of the growing season; A is the number of micromicrocuries of Sr^{90} per gram of calcium in milk, due to direct absorption, divided by the number of mc./mi.^{2} of Sr^{90} deposited during the growing season; and B is the number of micromicrocuries of Sr^{90} per gram of calcium in milk, due to the cumulative deposit, divided by the total mc./mi.^{2} of Sr^{90} deposited to the midpoint of the growing season since the start of nuclear testing. The coefficients A and B have the magnitude of 0.65 and 0.12, respectively.

In the fall of 1958 Soviet testing introduced about 1.3 megacuries of Sr^{90} into the Northern Hemisphere. This produced fallout of 14 mc./mi.^{2} from April 1 to October 1, 1959 and a total deposition to July 1 of about 16 mc./mi.^{2} (3). In the recent Soviet series of September-October 1961, it is estimated that 2.5 megacuries of Sr^{90} were introduced. Assuming that the rate of transfer of debris was about the same for the 1961 tests as in 1958, this would have produced fallout of 27 mc./mi.^{2} from April 1 to October 1, 1962 and total deposition to July 1, 1962 of about 31 mc./mi.^{2}. The recent report of Kuroda and Nix (4) suggests that this is a very good approximation. Resumption of tests by the United States will increase this even more.

Taking the Crosby silt loam soil as an example, and assuming fallout of 27 mc./mi.^{2} and total deposition of 31 mc./mi.^{2} we can estimate the number of micromicrocuries of Sr^{90} per gram of calcium in milk as follows:

$$\begin{aligned} Q_m &= AX + BY \\ &= 0.65 \times 27 + 0.12 \times 67 = 25 \text{ micromicrocuries of } Sr^{90} \text{ per gram of calcium in milk.} \end{aligned}$$

This estimated value is close to the average value of about 20 micromicrocuries of Sr^{90} per gram of calcium in milk for this region.

It would thus appear that the use of Cs^{137} as a monitor for Sr^{90} in soils would make possible rapid and extensive reconnaissance surveys of Sr^{90} concentrations in soils as well as in milk.

Acknowledgment

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Origin, Characteristics, and Management of the Soil Associations of Allen County

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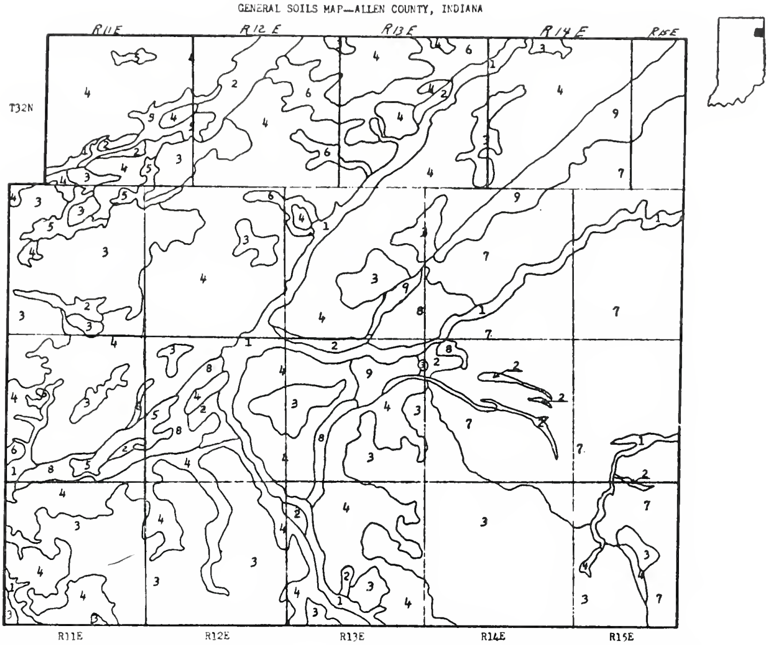
Allen County is located in the northeastern part of Indiana. Fort Wayne is the county seat. The county is bounded on the north by Noble and DeKalb counties; on the east by Paulding, Defiance and Van Wert counties, Ohio; on the south by Adams and Wells counties; and on the west by Huntington and Whitley counties. The county contains approximately 429,000 acres or 664 square miles of land area.

Pleistocene glacial deposits mantle the bedrock topography over the northern four-fifths of Indiana. The present surface features of Allen County are those characteristic of this glaciated region. They vary from low, level or depressed areas, remnants of old lakes, to rolling and hilly areas; the latter being the usual features of a morainic area. Glacial drift of the Cary subtage of the Wisconsin age glaciation covers Allen County. The drift varies from 50 to 200 feet or more thick; consisting predominantly of clay-rich till and minor amounts of outwash sand and gravel, aeolian sands and lacustrine materials.

The soils of Allen County will be more easily understood if they are first studied as they occur in broad areas, or soil associations (Fig. 1). A soil association is a geographic pattern of defined and named kind of soils. The soils in an association may be much alike or entirely different, but the pattern in which the soils occur is fairly uniform. The soils in this county have been placed in nine soil associations. The associations are named for the major soils in them, but other soils may be present in any of the associations. Each soil association is separated on the basis of its soil characteristics. However, the nine associations closely correlate with the past geologic history of the county, and each association follows somewhat a particular physiographic feature.

The Salamonie, Wabash and Fort Wayne moraines and scattered extensive ground moraines underlying soil associations 3, 4 and 6 constitute the upland areas in the county. Association 3 occupies the level ground moraines and associations 4 and 6 are the sloping moraine areas in the county. The lake plain area in the eastern part of the county contains soil associations 7, 8 and 9. Highway 37 northeast and Highway 30 southeast from New Haven have been constructed on the beach ridges that border the lake plain region. Most of the soils in association 9 occur adjacent to the beach ridges.

Of the major streams in glacial times, only two carried large quantities of outwash. Soil association 2 and part of association 5 in T32N, R11 & 12E include the outwash from the Eel River sluiceway. The Wabash sluiceway in T30N, R11 & 12E was formed during the maximum discharge and deposition of the Maumee Torrent when glacial lake Maumee occupied the lake plain region in eastern Allen County. This sluiceway is locally referred to as the Little Wabash River Valley. Soil associations 2, 5 and 8 occur here. Soil association 1 of bottom-



1-Genesee, Eel, Martinsville—Well drained river bottoms and terraces (0-3%).
2-Martinsville, Ockley, Belmore, Fox, Spinks—Well to excessively drained outwash soils.
3-Blount, Pewamo—Somewhat poorly to very poorly drained upland soils (depressional to 3%).
4-Morely, Blount—Well to somewhat poorly drained moderately sloping upland soils (3-10%).
5-Carlisle, Willette—Depressional organic soils.
6-Morley—Well drained steeply sloping uplands (10-20%+).
7-Hoytville, Nappanee—Very poorly to somewhat poorly drained level lake plain soils.
8-Lenawee, Toledo, Mahalasville—Very poorly drained depressional lacustrine and outwash soils.
9-Mahalasville, Whitaker—Very poorly to somewhat poorly drained outwash soils found on the lake plain (0-2%)

Figure 1. General Soils Map—Allen County, Indiana.

land and terrace soils occurs mostly along the major streams of the county. Following are more complete descriptions of each of the nine associations.

Association 1

Eel-Genesee-Martinsville: Light colored river bottom and terrace soils.

This soil association consists of nearly level river bottoms and terrace soils. It occupies about 4 percent of the land area in the county.

The soils here occur mostly adjacent to the major streams within the county. Small acreages of these soils also occur adjacent to smaller streams but in too small extent to be shown separately on this map.

About one-half of the association consists of the alluvial river bottom soils. The moderately well-drained Eel is the predominant soil series and comprises about 45 percent of the area. The well-drained

Genesee series comprises about 10 percent of the total area. Silt loams and silty clay loams are the main types of these two series with loams and sandy loams the minor types.

These soils are brown to dark grayish brown in color, neutral to alkaline in reactions, and high in fertility. They are developing in alluvium washed from highly calcareous glacial drift of the uplands. The main hazard in farming these soils is flooding and row crops are the main crops grown.

About 45 percent of Soil Association 1 is composed of terrace soils; the Martinsville being the major series. The Martinsville soils are well-drained, medium to strongly acid, and medium in fertility. They developed in stratified silty and sandy materials, are more acid, have more profile development, and are less fertile than the Genesee and Eel soils. However, there is no hazard of overflow except during time of exceptionally high water and they are used for general farm crops.

Association 2

Martinsville-Ockley-Fox-Belmore-Coloma: Well to excessively well-drained sandy and gravelly outwash soils.

Soils in this association developed on nearly level to strongly sloping outwash materials. They comprise about 3 percent of the land area of the county. The most extensive area is the gravelly outwash plain in T32N, R12E. Smaller areas occur throughout the county where glacial waters deposited the material many years ago.

The Martinsville soils are the major soils in this association and comprise about 40 percent of the area. They are well-drained, are developed in stratified silty and sandy materials, and occur throughout the area. Included are level areas of somewhat poorly drained Whitaker and flat or depressed very poorly drained dark colored Mahalasville soils described in Association 9.

The Ockley and Fox soils are well to excessively well-drained and are underlain by calcareous gravel and sand. The depth to gravel and sand ranges from 24 to 42 inches in the Fox soils and is greater than 42 inches in the Ockley soils. These soils are less extensive than the Martinsville and comprise about 15 percent of the association.

The Belmore soils occur on the beach ridges bordering the lake plain area of the county. They are well to excessively drained soils similar to the Fox and Ockley and are underlain by calcareous sandy and gravelly materials. State Highway 37 northeast and U. S. Highway 30 southeast of New Haven are built on these beach ridges which generally follow the lake plain border. Although Belmore soils comprise only a small area of this association, they make up a prominent land feature in the county.

The Coloma is also a minor soil in this association. They are excessively drained sands developed in wind blown or water-laid sand deposits which usually have a sand dune type topography.

Because the topography in this association ranges from nearly level to strongly sloping it has many different management problems. The coarser textured soils are droughty. The sloping soils are susceptible to erosion and the poorly drained soils require artificial drainage. There is also a wide difference in the fertility of these soils.

Nearly all of the important sources of gravel in the county are in this association.

Association 3

Blount-Pewamo: Nearly level, somewhat poorly and very poorly drained upland soils.

The soils in this association occupy about 26 percent of the county and consists of nearly level soils developed in till. This is the second largest association in the county.

The Blount and Pewamo soils comprise about 90 percent of Association 3. They occur throughout the upland areas but the largest areas are in the southern one-third of the county. These broad, level to gently sloping areas are associated with glacial ground moraines.

Blount and Pewamo soils developed in highly calcareous silty clay loam or clay loam till with clay content ranging from about 28 to 38 percent. These soils occur in an intricate pattern and differ mostly in natural drainage characteristics.

About half of the association is the somewhat poorly drained Blount soils on the slight rises in the level till plain. Blount soils have a grayish brown silt loam surface soil, mottled yellowish-brown clay loam to clay subsoil and are medium to strongly acid. The average depth to calcareous clay loam or silty clay loam till is 28 inches.

The Pewamo soils on the flat to depressed areas make up about 40 percent of this association. They have a very dark gray silty clay loam surface soil that is moderately high in organic matter. The subsoil is mottled dark gray and yellowish-brown, slightly acid to neutral clay. The average depth to the calcareous till is 49 inches.

Approximately 10 percent of this soil association is composed of other soils, primarily the Morley soils. They also developed from clayey till but occur on the more sloping, better drained area.

Soils of this association are used for cropland. Because of the level topography and clayey subsoil, drainage is the major management problem. Blount soils will respond well to lime and fertilizers. Pewamo soils, somewhat more fertile than the Blount soils, usually do not need lime, but will respond to correct fertilization.

Association 4

Morley-Blount: Well-drained and somewhat poorly drained level to moderately sloping upland soils.

The Morley-Blount is the major soil association and occupies about 37 percent of Allen County. It occurs throughout the upland areas with the major areas located in the northern two-thirds of the county. These gently sloping areas are associated with the glacial end or recessional moraines.

The Morley and Blount soils developed from highly calcareous silty clay loam or clay loam till. The Morley soils occur on the more sloping topography and the Blount soils occur on the level to gently sloping areas.

The Morley soils have a medium acid, grayish-brown silt loam surface soil up to 10 inches thick and a dark yellowish-brown clayey subsoil overlying the calcareous till at an average depth of 25 inches.

The Blount soils described in association 3 comprise about 35 percent of this association. Pewamo silty clay loam also described in association 3 occurs in depressions and drainage-ways of soil association 4. Scattered muck pockets in the lowest depressions are especially common in the northwestern part of the county. Alluvial soils along some of the small streams comprise a small proportion of this association and are of local importance to the farmers.

Soils in Association 4 are primarily used for general farm crops. The major management problems for soils in this association are erosion on the Morley soils and drainage on the Blount soils. They respond well to lime and fertilizer.

Association 5

Carlisle-Willette: Depressional organic soils.

This association consists of muck soils. It comprises about 2 percent of the area of the county with the two largest areas in the northwestern part of the county and in the valley west of Ft. Wayne. These soils are formed in wet, depressional, ponded positions.

Carlisle and Willette soils developed in partially to well decomposed remains of a marshy vegetation: reeds, sedges, water-tolerant trees and grasses. The deep Carlisle soil consists of 12 to 18 inches of black, granular, medium to slightly acid mucky material overlying the less well decomposed organic material. The Willette soils are similar to the Carlisle but are underlain by silty clay loam to clay mineral material at depths from 12 to 42 inches.

The Carlisle soils make up approximately 65 percent of the area while Willette soils occupy about 15 percent and occur mainly in the valley west of Ft. Wayne. Other minor soils included in this association are very poorly drained mineral soils like the Toledo, Lenawee, and Pewamo soils.

When artificially drained, these soils are very productive. Special crops such as mint and vegetables and cultivated row crops, mainly corn, are commonly grown. Large areas of this association are not cultivated because of high water table and difficulty in establishing outlets for drainage systems.

Association 6

Morley: Well-drained, strongly sloping uplands.

The Morley association occupies about 3 percent of the county. The soils in this association are well-drained upland soils developed from highly calcareous silty clay loam or clay loam till. They occur mostly on the strongly sloping areas. The Morley soils comprise approximately 60 percent of this association.

The major acreage occurs in the morainic area of T32N, R12 & 13E where much of the land ranges from 10-20 percent slopes and steeper.

The Morley soils, occurring also in Association 4, have a light colored, medium to strongly acid surface soil and a dark yellowish-brown clayey subsoil overlying the calcareous till.

Approximately 40 percent of this soil association is comprised of other soils, such as the Blount and Pewamo, that occur on nearly level to depressed, more poorly drained areas. Small muck pockets in the deep depressions are also present. Many of the depressions have lighter colored eroded materials from the surrounding Morley soils deposited on top of the dark colored soils.

This association is better suited to pasture or trees than to cultivated crops. In some areas that have been used for general farm crops, the soils are severely eroded. The short, very steep slopes along the stream breaks are best suited to woodland or wildlife areas.

Association 7

Hoytville-Nappanee: Poorly drained and somewhat poorly drained, clayey, lake plain soils.

This soil association occupies about 19 percent of the county and consists of level, very poorly to somewhat poorly drained clayey soils of the lake plain region. This association is composed of approximately 90 percent of Hoytville and Nappanee soils which are almost exclusively confined to the very level lake plain.

These soils developed in highly calcareous clayey till reworked and redeposited somewhat by the waters of glacial lake Maumee. The clay content of the limy parent material is greater than 38 percent. The Hoytville and Nappanee soils occur in close association and differ mostly in their natural drainage characteristics.

Approximately 70 percent of Association 7 is composed of the very poorly drained, dark colored Hoytville soils. The surface soil is a very dark gray clay that is medium-high in organic matter. The subsoil is a grayish clay overlying the high lime clayey till. The soil profile is slightly acid to neutral throughout.

The somewhat poorly drained Nappanee soils occupy about 20 percent of this association. They have a grayish brown silt loam or silty clay loam topsoil and a mottled yellowish-brown clay subsoil overlying the clayey till. The Nappanee soils require more fertilization than the Hoytville soils in order to produce comparable yields.

Minor soils in this association include the Pewamo and Blount soils. These soils are described in Soil Association 3.

The lake plain region is the best agricultural area of the county, and the land sells for as much as $500 to $700 per acre. The maintenance of adequate drainage systems and good soil tilth is of prime importance in management of these soils. They are generally devoted to a cash-grain system of farming and tile drainage is extensively used.

Association 8

Lenawee-Toledo-Mahalasville: Very poorly drained lake deposited soils.

This association consists of dark colored, very poorly drained clayey to silty soils of lake deposits or outwash soils occupying about 3 percent of the county.

These soils occur mainly in the Little Wabash River Valley west of Ft. Wayne and in the lake plain area northeast of New Haven. They also occur in a narrow, elongated area following Trier Ditch in T30N, R13E.

The most extensive soils, comprising about 80 percent of this association, are the Lenawee and Toledo soils. These soils are dark colored and very poorly drained but differ in clay content. The Lenawee soils developed from a silty clay loam lacustrine parent material; whereas, the Toledo soils developed from a silty clay or clay lacustrine parent material. Lenawee and Toledo respectively have similar textured parent material to the Pewamo and Hoytville soils but are developed on lake deposited material rather than glacial till deposits.

The Mahalasville soils are less extensive and comprise about 10 percent of the association. These soils are dark colored and very poorly drained. They developed from calcareous silty and sandy outwash materials.

The soils in this association are best suited to row crops and are productive when artificially drained. Maintaining good soil tilth is very important on these soils.

Association 9

Mahalasville-Whitaker: Poorly drained medium and coarse textured lake deposited soils.

This soil association makes up about 3 percent of the county. Most of it occurs in a narrow strip adjacent to and south of Road 37 from New Haven, northeast to the county line. Smaller areas are in the Ft. Wayne-New Haven vicinity.

The Mahalasville soils, which make up about 50 percent of the acreage, occupy the level to depressed areas. These soils are poorly drained, dark colored, and formed in stratified sands and silts. They have a very dark brown silty to loamy surface horizon that is usually neutral in reaction and moderately high in organic matter. They have good tilth and produce good crops when properly drained.

The Whitaker soils occur on the level to gently sloping area in an intricate pattern with the Mahalasville soils and comprise 35 percent of association 9. These soils are moderately deep and are somewhat poorly drained. They are formed from similar materials as the Mahalasville soils but have a less clayey surface soil, are lower in organic matter, and more acid in reaction. They are suited to most general crops grown in the area but in most cases have to be drained, limed, and fertilized in order to produce good yields.

Also in this association are Belmore soils that occupy the narrow inextensive northern beach ridges.

Summary

The soils of Allen County, Indiana, developed predominantly in clay-rich tills with minor soils developed in outwash sand and gravel, aeolian sands, and lacustrine sediments. Each soil association closely correlates with the past geologic history of the county; however, the soils are classified in terms of soil properties. The high clay content and very poor natural drainage are two soil characteristics of great importance in defining the proper management of the soils in Allen County.

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Some Aspects of Soils and Soil Survey on the Island of Maui, Hawaii

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Introduction

The Island of Maui is located near the eastern end of the Hawaiian Archipeligo. It is approximately 2,000 miles south of Alaska and 2,400 miles southwest of California.

Maui, like all the Hawaiian Islands, is of volcanic origin, and is mountainous. It has a low proportion of potentially arable land, and the arable areas are used very intensively. This has resulted in a highly specialized type of agriculture.

Maui is located on the north edge of the tropics, but is protected from summer temperature extremes by its position astride the trade wind belt (1). In addition to moderating the temperature, the trade winds also set the major rainfall pattern for Maui. Rainfall is characteristically high on the windward slopes and mountain peaks, but very low on the lower leeward slopes. Annual rainfall of over 350 inches has been recorded at Puu Kukuii on the West Maui peaks while long time average annual rainfall at Olowalu on the leeward coast is 15 inches.

Agriculture

Agricultural enterprises on leeward West Maui consist of one sugar cane plantation and one pineapple plantation. They presently have about 20,000 acres in these crops. Sugar cane grows best with maximum sunlight and large amounts of water. Pineapple also requires maximum sunlight but has a much lower water requirement than sugar cane. On leeward West Maui, sunshine is at a maximum along the coast but decreases drastically with rise in elevation toward the usually cloud-covered mountain peaks. Rainfall is very low along the coast but increases rapidly at high elevations. The agricultural land of leeward West Maui is confined to the rather dry, sunny, lower slopes. Higher slopes are not suited to sugar cane and pineapple production because of steepness and/or narrowness of the land surfaces between the gulches.

Except for one experimental field, all the sugar cane seen was irrigated. Water to irrigate the cane is collected from the high rainfall windward slopes and delivered to the production area through a complicated series of tunnels, ditches, and flumes. Irrigation engineers have their systems designed to apply approximately nine-acre-inches of water every two weeks.

Pineapple grows best in the 25 to 60 inch rainfall areas of West Maui. With rainfall less than 25 inches the plants show moisture stress and the fruit is reduced in size. None of the pineapple fields were irrigated. In rainfall above 60 inches disease becomes the limiting factor. Pineapple producers have rain gauges in many of their fields to compile rainfall data for use in correlating production problems and yields with production sites.

Soil Classification and Survey

Soils mapped during the survey of pineapple land of West Maui are currently classed as Low Humic Latosols, Humic Ferruginous Latosols, and Humic Latosols (1, 2). A predominant reddish-brown color, high clay content, relatively high organic matter content, high infiltration and percolation rates, and strong resistance to shear, are characteristics shared by soils in these three great soils groups.

Determining the actual proportions of clay in these soils is very difficult. (Clay as used here refers to very fine mineral particles). In the laboratory it is almost impossible to get soil samples completely mixed with water and dispersed so that the clay can be accurately measured. As a result many of the clay particles remain grouped together into small aggregates of silt size and are not measured as clay. Even so, the analyses give figures of 50 to 70 percent clay for many of these soils. This tendency of the clay particles to resist wetting and to remain grouped into silt size particles also makes it difficult for a soil scientist to determine the soil texture in the field. These tiny clumps of particles are still so durable even after continued wetting and hand rubbing that they give the soil a coarser feel and less stickiness and plasticity than laboratory data would indicate. The field soil scientist must then describe the apparent texture, based on wetting and hand manipulation of a soil sample and also the presumed texture, based on reference to soils with known composition.

The strong resistance to shear exhibits itself in banks and road cuts which stand vertically with minor slumping, sliding, or sloughing. This has a very practical importance to agriculture by imparting stability to the soil mass and thus preventing detachment of individual soil particles in the first stage of the soil erosion process. Resistance to shear becomes apparent indeed when one attempts to use a "sharp-shooter" spade to dig a pit for field study.

Organic matter is relatively high in comparison with light colored soils of the midwestern United States. Moreover, it is distributed rather uniformly throughout the top 3 or 4 feet of the soil rather than being concentrated in the surface layer. Few Low Humic Latosols have less than 3 percent organic matter, while the figure may rise to 8 percent for Humic Latosols.

Infiltration and water percolation rates for these soils are apparently extremely high. While few data are available to bear this out, the very low volume of runoff during and after a heavy rain can be qualitatively measured by on-site observations. The small amount of rainfall which does run off is often clear, or nearly so, even in freshly tilled fields. Infiltration and percolation rates, 3 to 10 times the average rates of soils in the midwestern United States, seem probable.

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ZOOLOGY

Chairman: James B. Cope, Earlham College
William Eberly, Manchester College, was elected chairman for 1963

The Southeastern Shrew *(Sorex longirostris)* in Indiana[1]

Russell E. Mumford and Charles L. Rippy, Purdue University and University of Kentucky

The southeastern shrew, (*Sorex longirostris*) is evidently a rare mammal in Indiana. Lyon (1936) knew of only three specimens, all from Knox County, collected in 1895 and 1910. Lindsay (1958) recorded the next specimen 48 years later from Jefferson County. In 1959, we took specimens in Marion and Tippecanoe Counties, and Don R. Helms trapped one in Fountain County. Subsequent trapping in Tippecanoe County by Arthur Johanningsmeier, David L. Herbst, Kenneth C. Nettles, and Rippy has now accounted for 13 additional specimens. The relative abundance of this shrew near Lafayette was unexpected, and the locality is the northern recorded limit of the animal's distribution in the midwest.

Shrews of the genus *Sorex* are usually difficult to trap in numbers by ordinary methods; it may or may not be significant that none was taken in Tippecanoe County in nearly 20 years of small mammal trapping prior to 1959. Three *longirostris* were captured on the Purdue Horticultural Farm in the spring of 1962. Long-eared Owls (*Asio otus*) regularly roosted on this area for many years and hundreds of their pellets were studied without finding *Sorex* remains (Kirkpatrick and Conaway, 1947). The remaining 11 Tippecanoe County specimens were trapped on the Purdue-Baker marsh, 10 miles west of Lafayette, an area not sampled by trapping prior to 1959.

Whether recent *longirostris* specimens represent relic populations cannot be determined with certainty. Past mammal collecting throughout the state has been sporadic, with few localities being intensively studied. Small, isolated populations of *Sorex*, or other small species, might go undetected for years; this may be the case with the southeastern shrew. On the other hand, the species may have a widespread distribution in Indiana, though seldom being taken in traps. The counties where specimens were taken are scattered; intensive work is now required within the limits of these stations in order to determine the true status of *longirostris*. Biologists living in this section of Indiana are urged to make an effort to obtain records of the species. Any small shrew of the genus *Sorex* from anywhere in Indiana should be preserved. The masked shrew (*Sorex cinereus*) occurs over most, or all, of the state, and it is distinguished from *longirostris* only by tooth and skull characteristics. Near Lafayette, 1 *cinereus* has been collected at the site where 11 *longirostris* were taken, but at other stations either one or the other species was found alone.

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[1] This is journal paper No. *2003* from the Purdue University Agricultural Experiment Station.

The habitats where *longirostris* have been taken in Indiana include (1) a barren fencerow bordering a close-cropped, upland pasture, (2) a small overgrown field containing scattered sprouts, rank weeds, and a seasonal (spring) damp area, (3) a marsh border vegetated with heavy grasses and weeds, and (4) a marsh area grown up to briars and bordering a small creek. All of the sites had some bluegrass as ground cover; otherwise, the habitats were not similar.

External measurements of *Sorex longirostris* from Indiana are as follows: 9 males—total length, 72-81 mm. (avg. 76.0); tail, 26-31 mm. (28.4); hind foot, 9-10.5 mm. (9.7). 5 females—total length, 77-86 mm. (80.1); tail, 28-30 mm. (28.8); hind foot, all 10. The weights of 8 males averaged 3.2 gm. (2.4-4.3); 3 females averaged 2.6 gm. (2.4-2.8).

There are no data pertaining to food habits, reproduction, or most other phases of the natural history of the southeastern shrew in Indiana. Males with the largest testes were trapped in late March and in April, suggesting that mating may occur in the spring. One animal was trapped between 10 a.m. and 1 p.m., indicating that the species may be diurnal to some extent. In Tippecanoe County, the southeastern shrew, masked shrew, least shrew (*Cryptotis parva*), and short-tailed shrew (*Blarina brevicauda*) have been taken in the same small area; how these species interact is unknown, but offers an interesting research problem. Of 20 *Sorex longirostris* specimens known from the state, 9 were caught in April, 3 in March, 3 in December, and 1 each in January, February, May, June, and October.

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The Occurrence of the Whistling Swan *(Cygnus Columbianus L.)* in Delaware County, Indiana

Robert H. Cooper, Ball State Teachers College

It seemed advisable to report the following information as a matter of record for the printed materials of the Academy since it is thought that the information might be of value to scientists doing research in the state of Indiana in the field of zoology, and especially in the field of ornithology.

On March 11, 1962, Mrs. Margaret Studebaker and Mrs. Arlene Carter of the Ball State Teachers College staff sighted thirteen whistling swans on the ice of the Prairie Creek Reservoir in Perry Township of Delaware County about six miles southeast of Muncie. This body of water was recently impounded by the Muncie Water Works by the building of a dam across the Prairie Creek Valley. It is approximately three and one-half miles long and one-half mile wide. It has one large arm of water extending east from the north end of the east side of the main reservoir. A concrete bridge crosses this arm near the main body of the reservoir so that persons driving along the east side of the reservoir have a fine observation point. This area is a rather protected and secluded area for water birds. On this day the swans were on ice on the west side of the reservoir. Mrs. Studebaker and Mrs. Carter contacted Dr. Robert Cooper, head of the Science Department of Ball State Teachers College, and Mr. Harold Zimmerman, Certified Public Accountant, Muncie, Indiana, who has long been a skilled observer in the field of ornithology.

On March 17th thirteen swans were still present on the reservoir as seen again by Mrs. Carter and Mrs. Studebaker.

On March 18th Mr. Zimmerman and Dr. Cooper made a special observation with field glasses and with Bausch and Lomb spotting scope to make more certain of the identity. At this time there were sixteen whistling swans. Some of them showed the gray marking of the young swan.

On March 22nd Mr. and Mrs. Pete Phillips of the Ball State Teachers College staff and Mrs. Studebaker again observed the swans and confirmed the observation of sixteen.

Again on March 24th Mrs. Carter and Mrs. Studebaker drove to the Prairie Creek Reservoir to make further observation and verified that there were still sixteen whistling swans on the water occupying the far eastern projection. Many ducks were present at this time including the redhead, canvas-back, ring-necked, lesser scaup, and shoveller.

On March 27th Dr. Cooper took an ornithology class of seventeen students to the area at 6 a.m. and saw twenty whistling swans circling over the body of water and then coming in for a landing on the water east of the bridge. At that time the ducks mentioned previously were present as well as buffle-heads, ruddy ducks, pintails, blue-winged teals, gadwalls, hooded mergansers, great blue herons, horned grebes, coots, pied-billed grebes, green-winged teal, and black ducks.

Early in the day on March 21st Mrs. Carter and Mrs. Studebaker made observations and counted twenty swans at that time.

On March 31st Dr. Cooper, along with others, was at the bridge observing the twenty whistling swans. Shortly after 5:30 p.m. all of the swans except two began to swim west toward the bridge. They came close enough that the yellow basal spot on the beak in front of the eye could be seen very readily, and the dull pinkish-black of the beak of the young could be seen as well as the gray on the necks. A lady in a car with an Ohio license stepped out and with her little camera and flash attachment took a picture. The observer does not know whether the flash caused the flock to take off at that time, but the birds did take off immediately to the east without two which were over on the margin of the lake. The flock circled two times over the area without being in formation. While doing that they picked up the two that were still on the water and immediately all of them started flying west to the bridge and were in perfect formation when crossing over the highway, with eight birds lined up on the left-hand side of the V as they angled northwest and twelve on the right-hand side. This was at 6:15 p.m., and it was getting dusk. The birds were not seen on the water after that. Presumably they were starting out on a night flight.

Those of us living in the Muncie area shall watch closely this autumn to see whether or not the whistling swans might stop on their southward journey.

Dr. Cooper and the students in the ornithology class wrote a letter to the mayor of Muncie urging him to try to shut off the neck of water where there were so many water birds in order to keep the sailboats and motorboats out of the area. No attention was paid to the letter so far as the authors of the letter knew. No reply was given. Those interested in ornithology will not only be watching this autumn for the return of water fowl, but also will be watching carefully the spring of 1963 to see whether or not the whistling swans return. The birds were present for at least twenty-one days on the Prairie Creek Reservoir.

The Effect of Parental Age on the Duration of Life of Mated and Non-mated Progeny in *Drosophila melanogaster*

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Introduction

The effect of mating frequency and periods of mating on the life span of the individual has long been noted. In a previous study on parental age effects in *Drosophila melanogaster* Meig. (Oregon-R strain) it was observed that continually mating offspring from old parents had a shorter adult life span than those from young parents (8). The present investigation was undertaken to determine the effects of parental age, if any, on non-mating offspring in this species.

Methods

All cultures were maintained in an incubator at 25° C. Adults of various ages from these stocks were placed in fresh culture bottles and eggs were collected for a period of 24 hours. The adults which emerged during the first 24 hours from these eggs were young from parents of various ages. Eggs were collected from these young adults during the first 48 hours following their emergence. The adults which emerged during the first 10 hours from this collection were used to set up the parental generation. The age of the parents was calculated on the basis of zero days at the time of the first adult emergence. Eggs were collected from this parental stock when the flies, allowed to mate freely from emergence, were 0 to 2 and 30 days old to set up the groups offspring from young and from old parents. The duration of the preimaginal stages was observed and the adults which emerged during the first 10 hours were divided into two subgroups consisting of mated and non-mated individuals. In this manner the virginity of the offspring was insured.

The flies were transferred to fresh culture bottles every four days. To avoid overcrowding there were never more than 30 flies per half-pint milk bottle for the mated stocks and 25 for the non-mated stocks. During this experiment a cornmeal-molasses medium was used with Dowicide$^{(R)}$ solution as a mold inhibitor.

Results and Discussion

Parental age had no effect on the duration of the preimaginal stages in *Drosophila melanogaster*. This observation is in agreement with previous studies in this species (1, 8). However, it was observed in the milkweed bug, *Oncopeltus fasciatus* (Dall.), that eggs laid by young and old parents required a longer developmental time than those laid by middle-aged parents (9). Studies on the mealworm, *Tenebrio molitor* L., have shown that parental age had no effect on adult longevity in individually housed offspring from isolated pairs of parents. However, larvae from young parents required a significantly longer time to complete development and had more molts than those from old parents

(5). In the dark mealworm, *Tenebrio obscurus* F., parental age had no consistent effects on the duration of the life cycle, but larvae from older parents seemed to have a slower rate of growth (3).

In Table 1 are shown the number of adult flies used and the average survival time for each subgroup at each parental age. Continually mated offspring from old parents had a significantly shorter adult life span than those from young parents, mated females from old parents showing a greater decrease in longevity when compared to that of the males. These studies are in agreement with similar work on the housefly *Musca domestica* L. and the vinegar fly *Drosophila melanogaster* where the offspring were allowed to mate freely from emergence (10, 4). However, this parental age effect on survival of continually mated offspring, derived from 30 day old parents, was not observed in *Drosophila subobscura* Col. through eight generations of selection (2). The present findings that non-mated individuals had a significantly longer adult life span than mated individuals is in agreement with the work on *Drosophila subobscura* where mated females had a lower life span than non-mated and ovariless females (7). However, in the present work mated males from young parents did not differ significantly from non-mated males. It was also noted in this study that there was no difference in the female and total survivals of non-mated individuals from young and old parents. However, non-mated males from old parents had a longer life span than those from young parents. Here selection in the males is in the opposite direction and the results are just statistically different. These observations are in agreement with other work in this species where mating was deferred in the offspring until the 21st day of adult life. The parental groups, obtained from at least five generations of selection from early and delayed matings, were mated immediately and at 21 days following eclosion. Offspring, in which mating was deferred, from continually mated parents 21 days old had a longer life span than from young parents. If the mating of the parents was delayed until the 21st day of adult life, there was no difference in the survival of these off-

TABLE 1. Average Survival Time (days) and Number of the Adult Flies. Values Are Given With the Standard Errors.

	Offspring from Young		Offspring from Old	
	Mated	Non-mated	Mated	Non-mated
Male	43.8 ± 0.94	43.2 ± 0.93	39.7 ± 0.70	46.2 ± 0.83
N	155	149	268	260
Female	41.5 ± 0.98	50.1 ± 1.29	33.5 ± 0.98	49.6 ± 0.96
N	116	137	131	170
Total	42.8 ± 0.68	46.5 ± 0.79	37.7 ± 0.57	47.5 ± 0.60
N	271	286	399	430

spring from young and old parents. There was no differentiation of sexes in this study (4). In both of these studies the offspring were reared in groups of 10 to 25 adults. In another work on this species, the parents were kept isolated and allowed to mate only 48 hours prior to the time of egg collection, ½ to 35 days following eclosion, the offspring also being kept isolated. Isolated offspring from old parents had a shorter survival time than those from young parents, this effect being noted when the female parent was 15 days or older (1).

Further studies in *Drosophila melanogaster* have led to the conclusion that aging and thermal effects on the rate of aging may be due to an accumulation of inhibitors and/or the exhaustion of necessary metabolites (11). It has also been noted in *Drosophila subobscura* that mated females at higher temperatures lived longer than those at lower temperatures. This is not in contradiction with the observation that poikilotherms live longer at lower temperatures, since egg production in these females at higher temperatures is about half of that at lower temperatures and these adults are less taxed physiologically (7). Comparative studies on the physiology of offspring from young and old parents in *Tenebrio molitor* have led to the conclusion that concentrations of activating ions and enzyme activity may be associated with nutrition and thus responsible for the parental age effects (6). Thus, parental age may have an effect on the nature of the metabolites in the offspring, the mating regimes involved and population densities effecting the utilization of these metabolites with subsequent effects on survival. It would seem that the offspring of *Drosophila* may reflect the physiological state of the parents and further work will involve the study of the nature and utilization of these metabolites stored in the eggs and the physiological state of the parents at the time of egg production. This assumption seems to be correct, since present work has shown a parental age effect on egg production and hatchability in these offspring.

Summary

The effect of parental age on the survival of continually mated offspring in *Drosophila melanogaster* (Oregon strain R) was compared to that of non-mated offspring. The duration of the preimaginal stages was unaffected by parental age. Continuously mated offspring from young parents had a significantly longer adult life span than those from old parents. Non-mated individuals generally had a significantly longer life span than mated individuals, non-mated females having a significantly longer survival time than non-mated males. Parental age, in general, had no effect on the longevity of non-mated offspring. However, non-mated male offspring from old parents had a longer life span than those from young parents. The results indicate that only in mating individuals does the life span decrease with an increase in parental age.

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Notes on the Ecology of the Milliped, *Pleuroloma butleri* (McNeill) in Migration[1]

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The phenomenon of milliped migration has been observed several times over many years. Three earlier instances have been recorded for Indiana. Mauck (3) in 1898 reported a large aggregation of *Fontaria virginiensis* on the bank of Lake Wawasee near Syracuse, Indiana about four miles from the site of those to be reported herewith. Williams (5) in 1951 reported an aggregation of *Zinaria butleri* near Spencer, Indiana. Young (6) in 1958 reported an aggregation of larval forms of *Zinaria butleri* at Nashville in Brown County. Cloudsley-Thompson (1) cited the occurrence of as many as fourteen migrations of millipeds in West Virginia, half a dozen in other parts of the United States and many in various parts of Europe.

It should be pointed out that the synonomy of the Myriapoda is confused and that the genus *Pleuroloma* which is discussed in this paper is identical with the *Zinaria* of Williams and of Young.

On the morning of September 1, 1962, I found a considerable number of specimens of the milliped, *Pleuroloma butleri* (McNeill) on the road in front of the laboratory of the David Worth Dennis Biological Station of Earlham College on Dewart Lake near Syracuse, Indiana. They appeared to be coming from a nearby cattail swamp at the edge of the lake. In general, they were travelling uphill. Shortly many thousands were occupying the grassy areas on the hillside. They piled up, several deep, where they were trapped by a cement wall and by the side of a laboratory building.

The animals were adult but only about ten percent had attained the full coloration indicating complete maturity. After a few hours the animals were dispersed over a wide area. In a day or two only occasional stragglers were to be found.

On September 3 (Labor Day), I saw another extensive aggregation in a glacial kettle hole about a hundred yards from the above mentioned site. The animals had a larger proportion (approximately half) with full coloration. The observation of this colony was interrupted by the burning of much of the ground cover by the owners.

On September 9, a neighbor called my attention to a large accumulation of millipeds along a stone wall in his yard. This was the most numerous of all the aggregations seen. In places the worms were piled several inches high. They were intermediate in degree of coloration between the first two aggregations. A slight rain in the previous night had left several shallow puddles on a cement walk. Animals moving through the water showed no instinctive reaction against it but many drowned in as little as a half inch of water.

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1. The identification of this milliped was made by Dr. Nell B. Causey, to whom I am indebted.

Finally, on September 10, I found a fourth aggregation crossing the road at the site used by the first. These animals were the most mature of all, more than half having full coloration. They dispersed quickly after the sun came out.

In all these instances the nights and mornings were humid and overcast. The cattail swamp from which they came was unusually dry, the lake having the lowest level of several years.

Since the millipeds were almost continuously under observation for more than a week I was able to make a number of ecological observations. The animals are scavengers, eating their way through soil. The earlier castings were very black, being composed of the muck from the swamp. Later castings formed from upland soil were much lighter. In some places the ground was covered completely by castings. They are very distinctive. Being dropped in a semi fluid condition they flatten out to form little patties with turned-up rims. Much of the woodland mull nearby appeared to be composed of more or less entire milliped castings. Eaton (2) and Romell (4) have discussed the mull forming capacities of millipeds. Microscopic examination of castings showed that the animals were indiscriminate eaters. The castings included many sand grains and woody fragments. It was often possible to hear the crunching sound of their chewing activity.

In the migration pattern of the millipeds I could detect little or nothing of a social instinct. I saw no instances of mating. When two animals came in contact, one would glide over the other with only a bare slackening of pace or change of course. The aggregations seemed fortuitous as the animals were stopped by obstacles. Beside a brick chimney they chewed out cavities in the soil into which two to eight individuals crowded, apparently to escape from light, although they lacked eyes. The greatest activity was at night. All aggregations appeared in early morning and the animals tended to disperse as the light became strong. Several groups, numerous in grass in the evening, had disappeared by the following morning. In the laboratory, they congregated in the darkest part of their containers.

The presence of such a large number of animals appeared to be the result of an unusual rate of survival. The swamp from which they emerged was the driest it had been for many years. The susceptibility to drowning in very shallow water leads me to believe that usually there is a high mortality among migrating individuals and that the unusual dryness led to a phenomenal survival rate, hence the conspicuous migrations. This conclusion is in accord with suggestions by earlier writers.

I hope that further observations will be recorded, in order to determine more accurately the nature of the stimulus to the sudden change in population.

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A Simple Method for Collecting Hydra

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For many years the author collected living hydras from a stream which flowed out of Sager's Lake located near the campus of Valparaiso University. At the west end of the lake there is a dam that was built many years ago to raise the level of the lake to provide water to power a mill located to the south of the dam. The mill was used during World War I but has since been torn down. Water was fed to the mill by means of a large metal tube and the water's flow was controlled by a gate valve. Although the mill is no longer in existence, the gate valve is used to control the flow of water from the lake and thereby to control the level of the lake.

During the period when the water level was maintained at the top of the dam, water flowed over the dam and down a stream bed that was approximately 12 feet across and a few inches to several feet deep in most places under ordinary conditions. The stream provided numerous small, shallow, quiet places where hydras could be found attached to roots, leaves, rock, etc. throughout the year. Immediately after a heavy rain the amount of water flowing over the dam increased considerably and washed out the hydras located in the stream. Soon after the high waters subsided, hydras could again be found, suggesting that the organisms were being carried from the lake in the usual flow of water over the dam.

Some time ago the Sager's Lake property was purchased by a private club and more recently they have been maintaining the lake level at a somewhat lower stage than formerly by opening the gate valve and channeling the flow down a narrower channel through which the water flows so rapidly that hydras have not been able to establish themselves.

Since teachers, practice teachers, high school students, and others are frequently seeking hydras for classroom demonstrations, experiments, and projects, the author decided to try to trap hydras from the rapidly flowing stream. Several thicknesses of women's hose were arranged so that the upper part of the leg was attached to the one end of a piece of field tile. The hose were then passed through the tile, a large knot made in them at about the ankle, and a one-half pint milk bottle passed down to the knot with the open end facing the tile. The hose was secured around the neck of the bottle with several rubber bands. This device, similar to a plankton net and which might be called a hydra trap, was then placed in the swift current so that water would flow into the tile and hose opening and be strained as it passed through the mesh of the hose. The trap was then left in the current for periods of several hours or over night. When the trap was removed from the water the contents of the jar were poured into a gallon glass jar which was filled with tap water and examined. When first examined numerous small crustacea could be observed but hydras were not in evidence, which was somewhat disappointing. However, when the sides of the jar were examined from day to day, after about a week to ten days, numerous hydras appeared on the sides of the jar. Budding soon became very common.

By using this method, it has been possible to secure living hydras at every season of the year. Since large hydras were not visible immediately after empyting the trap into the jar, one wonders what is happening. One likely explanation is that hydras which have become detached from their substrates have floated down from the lake to the outlet tube and, upon being caught in the trap, have fragmented to the extent that it is not possible to see them macroscopically and that such fragments have then regenerated to form complete animals. Another explanation is that dormant embryos are being carried down with the current and trapped and that conditions in the jar make it possible for them to develop into adults. When first noticed the hydras are quite small and possess fewer tentacles than the typical adults. It is suggested that wherever a rapid stream is flowing from a lake or pond that this method of collecting hydras be tried as a possible easy, dependable, and inexpensive source of living hydras.

Some Effects of Nonoptimally High Incubation Temperatures on Chicken Blood Chemistry[1]

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Introduction

Chicks hatched from eggs incubated for varying numbers of days initially or terminally at 41° (all temperatures are reported as centigrade) have shown significant reduction in body weight when compared with control animals hatched from eggs incubated under normal temperatures of 37.5° for the entire incubation period (8). Marked behavioral aberrations have also been noted in the same birds (7, 9, 10, 11).

In an effort to assess at physiological levels the extent and nature of damage to the nervous system caused by the heat treatment, pilot biochemical investigations have been initiated. The first type of tissue studied was blood, since observations to date have indicated its involvement in a number of ways: the blanching of combs and wattles, the inability or apparent inability of temperature-stressed chicks to regulate body heat effectively (unpublished data), and the tendency of experimental birds to huddle (11). Consequently, this report is based upon results obtained through tests of hemoglobin, blood sugar, blood lactic acid, and hematocrit.

Materials and Methods

Group I chicks

Three hundred twenty-two White Leghorn (DeKalb) eggs were incubated for the first 3 days at 41° and were then placed in a normal temperature incubator at 37.5° for the remainder of the incubation period. Sixty-three chicks hatched under these conditions. (All such temperature-stressed chicks are referred to as experimental animals.) Of 96 eggs incubated at the normal temperature of 37.5° for the entire incubation period, 60 hatched. (All chicks incubated at optimal temperature are referred to as control animals.)

When the birds were 4 weeks old, 15 experimental and 15 control animals were selected at random for hemoglobin determination. The direct photometric method for hemoglobin, as described by Hawk, et al. (12), was used. The addition of a small amount of hydrochloric acid (2, 4, 14, 16) was found necessary in order to decrease the turbidity of the solution.

For determination of blood sugar, 5 control and 5 experimental animals were selected at random from the chicks not used in hemoglobin tests. These chicks were 5 weeks old when tested. The micromethod of Folin and Malmros for blood glucose, as described in Hawk, et al. (12), was used. Prior to the tests the birds were deprived of food but not water for 6 hours.

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Group II chicks

These chicks were hatched from a different lot of White Leghorn (DeKalb) eggs under the same conditions as those in Group I. Of the 276 eggs exposed to 41° for the first three days of incubation, only 13 hatched. Forty-nine control birds were obtained by incubating 84 eggs at normal temperatures. Eleven control and 11 experimental chicks were selected at random for all of the blood tests. Hemoglobin and sugar tests were run on the blood of these chicks, as described above for Group I. Blood lactic acid was determined by the micromethod of Natelson (15). The hematocrit values were ascertained by the Guest-Siler (6) technique, as modified by Johnston (13). Tests were run when the chicks were 4, 6, and 13 weeks of age. Prior to the tests the birds were deprived of food but not water for 6 hours.

Group III chicks

This group of 60 chicks (30 experimentals and 30 controls) was selected at random from a third lot of White Leghorns (DeKalb). Incubation conditions of the eggs from which these chicks were hatched were the same as those described for Groups I and II. A total of 68 chicks was obtained from 492 eggs incubated for the first 3 days at 41°, and 65 chicks were obtained from 108 eggs incubated at normal temperatures for the entire incubation period.

When these chicks were 2 weeks old, hemoglobin, sugar, lactic acid, and hematocrit values were determined by the methods described for Group II chicks. Prior to the tests the birds were deprived of food but not water for 6 hours.

For all groups, venous blood was obtained from the right atrium or ventricle and was ejected from the syringe into a heparinized-oxalated test tube. The blood used for each specific test was pipetted from the test tube by appropriate micro-pipets. For the hematocrit, blood from the same source was obtained in heparinized capillary tubes. All tests were begun immediately after the blood was withdrawn from the heart. Time was a particularly critical factor in the case of lactic acid tests, so that glycolysis, which would result in the conversion of blood sugar to lactic acid, would not occur and thus give false values. However, it was inevitable that attempting to run the tests simultaneously would result in some time lag.

Since comparative results rather than absolute values were desired, the blood pipets were not recalibrated, although care was taken to insure that the experimental groups were tested with the same pipets as those used on the control groups. In other words, pipets were randomized within groups, but the same pipets were used among groups. A further precaution observed was that of using the most accurate pipets obtainable, either class "A" or those certified by the Committee on Microchemical Apparatus, Division of the American Chemical Society.

Results

The results of blood glucose and hemoglobin tests of Group I chicks are shown in Table 1. The mean values for the control chicks are higher in the cases of both types of tests. Student's "t-test" elicited

TABLE 1. Ranges and means of blood tests of Group I chicks and results of Student's "t-test."

Blood constituent		Controls	Experimentals
Glucose (mg/100 ml blood)	Range	137.0-186.0	101.0-134.0
	Means[2]	155.8	115.2
	Number of chicks tested, all 5 weeks old	5	5
Hemoglobin (g/100 ml blood)	Range	4.2-10.0	1.4-9.8
	Means[3]	8.9	5.0
	Number of chicks tested, all 4 weeks old	15	15

[2] Highly significant difference: df = 8; t = 3.671; $P < .01$

[3] Highly significant difference: df = 28; t = 5.097; $P < .001$

values of t which were highly significant for these mean differences ($P<.01$ for sugar; $P<.001$ for hemoglobin). Error variances were tested by the "F-max" procedure and were found to be homogeneous.

The chicks in Group II were tested for all 4 blood constituents: sugar, hemoglobin, hematocrit, and lactic acid. Table 2 summarizes the results of these tests. It is seen that the mean values for hemoglobin, hematocrit, and lactic acid are higher for the control than for the experimental animals. However, experimental birds have higher mean blood sugar values than do control birds. Analyses of variance failed to yield significant F-values for hemoglobin, hematocrit, and blood sugar. Since the error variances for the lactic acid data were non-homogeneous by the "F-max" test, the mean difference for this blood component was tested by means of "the t-test for samples with non-homogeneous error variances" as described by Edwards (3), which elicited a significant value of t ($P<.05$).

The birds in Group III consisted of 30 controls and 30 experimentals; it is emphasized again that all tests for this Group were run simultaneously. Table 3 is a summary of the test results for Group III. While the means for glucose and for lactic acid are higher for the controls, the means for hematocrit and hemoglobin are higher for the experimental animals. Analyses of variance failed to yield significant values of F for glucose and hematocrit, but the F-values for hemoglobin and lactic acid are significant ($P < .05$ and $P < .01$, respectively), with hemoglobin content higher for experimentals and lactic acid higher for controls. For these data, error variances are homogeneous by the "F-max" test.

TABLE 2. Ranges and means of blood tests of Group II chicks and results of "t-test" and analyses of variance.

Blood constituent		Controls	Experimentals
Lactic acid (mg/100 ml blood)	Range	3.7-8.4	3.5-4.7
	Means*	5.6	4.2
	Posthatching age of chicks	4 weeks	4 weeks
Glucose (mg/100 ml blood)	Range	54.2-208.5	54.2-188.5
	Means (NS)$_1$	125.1	147.2
	Posthatching age of chicks	6 weeks	6 weeks
Hemoglobin (g/100 ml blood)	Range	7.3-9.9	6.6-11.3
	Means (NS)$_2$	8.8	8.2
	Posthatching age of chicks	13 weeks	13 weeks
Hematocrit (% volume packed red blood cells)	Range	29.0-33.8	28.4-33.5
	Means (NS)$_3$	31.9	30.7
	Posthatching age of chicks	6 weeks	6 weeks

*Significant difference: $t = 2.604$; $P < .05$ ("t-test" df = 20)
(NS)$_1$ Not significant: $F = 1.216$; $P > .05$ Analyses of variance df:
(NS)$_2$ Not significant: $F = 1.450$; $P > .05$ Between Groups = 1
(NS)$_3$ Not significant: $F = 3.239$; $P > .05$ Within Groups = 20

Discussion

The reliability of the methods used in these determinations might be questioned on the basis that other techniques exist which would give more accurate results. A comparison of the means and ranges of the data for controls with "standards" (1) indicates that the hematocrit and hemoglobin values reported herein compare favorably with results obtained by other and similar methods (2, 4, 13, 16). The blood sugar values differ markedly in mean and minimal values, but maximal glucose content compares favorably with "standards" (1). The authors were unable to find a "standard" value for chicken blood lactic acid in the

TABLE 3. Ranges and means of blood tests of Group III chicks and results of analyses of variance (all chicks 2 weeks old).

Blood constituent		Controls	Experimentals
Lactic acid (mg/100 ml blood)	Range	0.4-3.6	0.05-3.1
	Means**	2.3	1.0
Glucose (mg/100 ml blood)	Range	108.7-193.1	113.0-186.2
	Means (NS)$_1$	151.8	146.3
Hemoglobin (g/100 ml blood)	Range	5.1-11.4	6.2-11.4
	Means*	8.2	9.0
Hematocrit (% volume packed red blood cells)	Range	22.6-39.3	23.7-36.5
	Means (NS)$_2$	28.1	29.9

*Significant difference: F = 4.400; $P < .05$
**Highly significant difference: F = 10.013; $P < .01$
(NS)$_1$ Not significant: F = 1.021; $P > .05$
(NS)$_2$ Not significant: F = 1.126; $P > .05$
df Between Groups = 1; df Within Groups = 58

literature. Perhaps it is unnecessary to point out again that absolute values are not of particular interest in this research, since the comparison between the values for control and experimental animals is of prime concern. In fact, the optical density values alone, as read from the spectrophotometer, could have supplied equally valid information from the comparative viewpoint. The reproducibility of these values must await further research. As far as studies conducted to date are concerned, it appears that the results can be reproduced within the limits of biological variability. Further investigation is currently in progress in an attempt to verify this.

When the glucose values for the chicks of Group I (Table 1) are compared with those for the chicks in Groups II and III (Tables 2 and 3, respectively), there appears to be some inconsistency. While the differences in glucose between controls and experimentals of Group I reflect a highly significant reduction in blood sugar in the experimentals, the difference for the Group II animals reveals an opposite effect—an increase in sugar content of the blood of experimentals. This increase, however, is not significant. The experimentals in Group III show a lower blood sugar content, but the difference again is not significant. The appropriate interpretation of these findings appears obscure at the present time. The smaller amount of glucose in Group I animals could be a reflection of inherent organismic variability which may have resulted in statistical significance because of the small number of animals employed (5 in each lot). Possible procedural errors might also account for the conflicting results. On the other hand, it is entirely possible that the differences obtained are reliable and that they appear only at certain times. Each lot of chicks might manifest a different order of appearance and magnitude of these defects. The different groups of chicks were not all tested at the same ages, and thus age may also be a factor in the onset of these differences. Further tests must be conducted in order to make a final decision. Speculation on the implication of significant differences in sugar content would be premature prior to resolution of the apparent inconsistencies in the data.

The accurate determination of hemoglobin in chicks is particularly difficult because of the turbidity of the solutions which is caused by the nucleated red blood cells. However, this undesirable feature is eliminated by the method used, and satisfactory results can be readily achieved and rapidly reproduced. Total hemoglobin is measured, and the values obtained probably do not accurately reflect the absolute hemoglobin content.

The highly significant reduction in hemoglobin content of the experimental chicks in Group I is contradicted by a significant increase in hemoglobin in the experimental chicks in Group III. While the mean is lower for Group II experimental birds as compared with controls, the difference is not significant. What makes this puzzling and certainly unique from a statstical viewpoint is that the number of chicks from all groups is ample for statistical sampling. It is unfortunate that the hematocrit was not taken on the blood of the Group I birds, for in the Group III birds the ratio of packed red blood cells to total serum volume was greater (but not statistically significant) in the experimentals than in the controls. One could almost predict this in view of the significant increase of hemoglobin in the experimentals. Any consistent difference in hemoglobin would have to be investigated further with respect to the red blood cells. Are the latter different in number, size, or development? Has their oxygen-carrying capacity been impaired or enhanced in the case of the experimentals? The hematocrit can give information relative to number and size of red blood cells, but it cannot distinguish between them. In passing, it can be noted that the means for hematocrit obtained of chicks in Groups II and III are remarkably similar, and they appear to be positively correlated with the means for hemoglobin.

The test for blood lactic acid gives the most consistent results. Although this test has been given to only two different hatches of chicks, the total number of chicks tested (82 in the two groups) is quite impressive from the standpoint of biological numbers and lends credence to the reliability of the results of statistical analyses. In both Groups II and III the experimental birds have mean values for blood lactic acid which are significantly lower than those for the control birds. To be sure, the means and ranges are quite dissimilar in the two groups, but so are their ages. In view of what one is tempted to call the "retarded mentality" of the experimental chicks, their lowered blood lactic acid appears to be highly significant. However, what precise effect (if any) this has on the brain or behavior of the hatched chicks remains obscure.

The brain absorbs lactic acid as well as glucose from the circulating cerebral blood. Lactic and pyruvic acids, the principal end products of anaerobic glycolysis, are resynthesized to glycogen during the aerobic phase. Presumably, this reconversion of lactic and pyruvic acids to glycogen occurs in brain cells as well as in muscle. However, the brain stores little, if any, glycogen. Consequently, the brain must rely almost entirely on free blood glucose for anaerobic glycolysis. This implies that there must be a readily available supply of free blood sugar to the brain at all times. (Perhaps the glucose-lactic acid route is not used to any appreciable extent by brain cells, or is not the only one traveled in brain metabolism.)

The sensitivity of the brain to lack of sugar is well known. Lactic acid effects are not so well documented, however. Blood lactic acid increases considerably during violent exercise but decreases rapidly during the resting phase. Pathologic increases in blood lactic acid are noted whenever a deficiency of oxygen occurs (hypoxia). Recently Grabowski (5) has shown that lactic acid accumulation induced by subjection to hypoxia is responsible for abnormal development in chick embryos. He further indicated that direct application of lactic acid to the embryo produced results similar to those induced by hypoxia. His hypoxia- and lactic acid-induced malformations produced embryos with severe edema followed by formation of cutaneous blisters and hematomas. In work previously reported by Gunther and Jones (8) it was found that chick embryos subjected to abnormally high temperatures for the first 5 days of incubation were significantly heavier and more advanced in development than controls. Some of these embryos resembled those described by Grabowski (5), particularly with respect to the general edema and to the formation of subcutaneous blisters. As a purely speculative interpretation, it is quite possible that this condition in our embryos resulted from lactic acid accumulation, although it is difficult to conceive of a lack of oxygen in our experimental set-up.

If there is a lactic acid accumulation in the heat-stressed embryos, and if the heat treatment somehow causes a lowering of the oxygen supply (perhaps through loss of hemoglobin), there would appear to be a remarkable transformation of embryonic biochemical processes to just the opposite effect in heat-stressed hatched chicks. As indicated in Tables 2 and 3, there is a decrease in blood lactic acid of Groups II and III experimental chicks from that of the controls, and an increase in hemoglobin of Group III experimental chicks over that of the controls. The increased hemoglobin content of the blood of the Group III experimentals over that of the control chicks agrees in theory with the decreased blood lactic acid in the experimentals from that of the controls. That is, increased hemoglobin content of the red blood cells could make available more oxygen for reoxidation of reduced diphosphopyridine nucleotide (DPNH) through the riboflavincytochrome hydrogen transfer system (DPNH→DPN). This might increase lactic acid dehydrogenase activity so that the equilibrium between lactic and pyruvic acids is disturbed. The net result would be a lowering of lactic and an increasing of pyruvic acid content in the blood. We found a consistent and significant decrease in blood lactic acid of the experimentals from the controls, but did not run tests for pyruvic acid. Our current research activity focuses also on this problem. The simultaneous determination of blood pyruvic and lactic acids in hatched chicks may shed some light. Also, determination of lactic and pyruvic acids in the blood of embryos during the first five days of incubation at the nonoptimally high temperature (41°) may yield information as to whether the edema and subcutaneous blisters are caused by lactic acid accumulations. At any rate, it seems reasonable to assume that the short-term nonoptimally high incubation temperatures cause alterations either in metabolic pathways or activity.

Summary

Chickens were permitted to hatch from eggs which had been placed in a nonoptimally high temperature of 41°C. during the first 3 days of the incubation period, and from eggs which had been incubated at the same time at normal temperature (37.5°C.) for the entire period.

The hatched chicks were tested at different ages for hemoglobin, blood sugar, blood lactic acid, and the hematocrit.

In two groups of chicks hatched from eggs at different times, hemoglobin values differed significantly between the control and experimental birds. In one group the blood of heat-stressed chicks contained less hemoglobin than the blood of control chicks. In the second group of heat-stressed chicks the hemoglobin content was higher than in the controls.

Blood glucose levels were significantly lower in one group of heat-stressed animals than in controls. Differences among other groups were present but the mean differences failed to attain significance.

The hematocrit was similar for all groups investigated, and means did not differ significantly.

Blood lactic acid measured significantly lower in heat-stressed birds than in controls in all groups studied. One experimental group with a significantly lower blood lactic acid content had a significantly higher hemoglobin content than did control chicks.

These data are compared with available "standards." Discussion of the significance of these differences relative to aberrant behavior and to retarded mentality centered around the possible biochemical mechanisms involved.

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Some Dietary Factors in Experimental Liver Cancer

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Introduction

Feeding azo dyes in purified diets leads to development of lesions and eventually to liver cancer. Several derivatives of 4-dimethylaminoazobenzene have been tested for comparative carcinogenicities and a most effective compound was found to be 3'-methyl-4-dimethylaminoazobenzene (1).

Most dietary formulas used in azo dye carcinogenesis during the past twenty years involved addition of the dyes to semi-synthetic diets containing highly processed ingredients coupled with low quantities of riboflavin (1, 2, 3, 4, 5). It has been reported that diets deficient in riboflavin were conducive to tumor development, whereas tumors developed more slowly, or failed to appear in the experimental period, when dietary levels of riboflavin were increased (1, 5). That analogs of riboflavin inhibit flavoenzymes or influence riboflavin metabolism in a variety of biological systems (6) provides reasoning along the lines that addition of such analogs to diets containing azo dyes would modify the course of carcinogenesis and perhaps accelerate the carcinogenic process.

The primary purpose of the experiments reported here was to determine whether 3'-methyl-4-dimethylaminoazobenzene (3'-Me-DAB) would retain its carcinogenicity in rats fed a non-processed stock diet adequate in all dietary components, including riboflavin. Also, since 6, 7,-dimethyl-9- (2'acetoxyethyl)-isoalloxazine (U-2112) was shown to be an effective riboflavin antagonist (7) another purpose of these studies was to determine whether this analog could change the susceptibility of rats to the carcinogenic influence of 3'-Me-DAB.

Materials and Methods

Mature rats of the Wistar strain were fed a powdered commercial diet prepared from pellets produced by Pilsbury's Ltd. The dietary ingredients were natural products consisting primarily of whole grains, dried milk, yeast, molasses, salts, cod liver oil; and meals of meat, bone, and fish. On Friday of each week, the dried food was withdrawn and the rats given fresh greens.

Mature rats were divided into three groups and treated as follows: group 1 consisted of 6 male and 6 female controls fed stock diet to which no chemical agents were added; group 2 consisted of 5 males and 6 females fed azo dye mixed in the stock diet; group 3 consisted of 5 males and 5 females fed stock diet containing azo dye and riboflavin antagonist (U-2112). The dye (3'-Me-DAB) comprised 0.06% of the diet for groups 2 and 3 and the riboflavin antagonist was mixed into the diet in a concentration of 20 mg/kg diet and fed to rats of group 3 for 3 weeks; the concentration was raised to 1 gm/kg and fed for another 5 weeks.

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[1] The author wishes to thank Dr. H. G. Petering of the Upjohn Company for generous supplies of the riboflavin analog used in these studies.

He is also indebted to Dr. Ceasare Biancifiore of the University of Perugia, Italy, for reporting terminal findings on rats fed riboflavin analog.

Animals were maintained on dietary regimes for periods varying from 125 to 131 days or approximately 4 months. Rats in group 3 received riboflavin antagonist during the first two months only but they were given 3'-Me-DAB for a 4 month period.

During the course of the experiments, rats were checked daily and weighed periodically. At the termination of the experiment the rats were weighed, sacrificed and bled from the juglar vein. The livers were weighed, examined macroscopically for lesions and portions of the liver were removed for microscopic study.

Results

As can be seen in the tables, both male and female rats on the stock diet (group 1) gained appreciably in body weight over the 4 month experimental period, thus indicating the adequacy of the stock diet. Livers of these animals were normal in all respects.

Males maintained on the diet containing 3'-Me-DAB (group 2) gained less weight than controls, whereas females lost weight on this regime. On a body weight basis the livers of both males and females were slightly larger than those of controls. Livers from all males had easily detectable lesions and microscopic examination of all such lesions revealed adenocarcinomas. Lesions were present in 4 of 6 livers from females but such lesions contained no cancers. These lesions were probably of a precancerous nature; histologically they consisted of hypertrophied, inflammed, and degenerate liver cells.

In group 3, the males fed azo dye and riboflavin analog in the diet gained as much weight as control rats, and females on the same regime showed a weight gain, but somewhat less than that observed in controls. Livers from either sex showed no signs of enlargement, being about the same weight as livers from controls. In examining the livers in this group, 4 of 5 livers from males showed lesions but none of the female livers appeared abnormal. Lesions in the male livers consisted of whitish blotchy areas on the surface with little indication of nodule formation. They were less distinctive than lesions observed in livers from males of group 2 (azo dye but no riboflavin analog). Although none of the livers in this group exhibited carcinomas there were histological signs of degeneration in most of the livers of both sexes. Cellular hypertrophy was lacking, but increased in connective tissue and fatty infiltration was obvious in the livers from 3 males and 4 females.

Discussion

Results of these experiments show clearly that azo dye carcinogenesis will take place in male rats fed a stock diet containing 3'-methyl-4-dimethylaminoazobenzene. Liver enlargement, after 4 months of azo dye feeding, is not as great as that seen when the dye is fed in a semi-synthetic diet low in riboflavin (8) and the degree of neoplastic involvement is less. Tumor development took place more slowly in animals fed stock diets and azo dye, but extension of the experimental period probably would have resulted in increased size and number of carcinomatous areas.

TABLE 1. Mean body weights of rats fed various diets for four months.

Group	Diet	Sex	No.	Initial B.W. g	Final B.W. g	B.W. change g	Liver wgt. g
1	Stock	Male	6	340	443	+103	15.2
2	Stock + azo dye	Male	5	262	328	+ 66	13.6
3	Stock + azo dye + riboflavin analog	Male	5	188	303	+115	9.1
1	Stock	Female	6	330	419	+ 89	13.6
2	Stock + azo dye	Female	6	290	276	— 20	9.7
3	Stock + azo dye + riboflavin analog	Female	5	224	267	+ 43	8.3

TABLE 2. Macroscopic and microscopic changes in livers of rats fed azo dye for four months.

Group	Diet	Sex	No.	Liver wgt. g/100g B.W.	No. with lesions	No. with carcinomas
1	Stock	Male	6	3.5	0	0
2	Stock + azo dye	Male	5	4.1	5	4
3	Stock + azo dye + riboflavin analog	Male	5	3.1	4	0
1	Stock	Female	6	3.1	0	0
2	Stock + azo dye	Female	6	3.6	4	0
3	Stock + azo dye + riboflavin analog	Female	5	3.1	0	0

The finding that most females on this dietary regime showed lesions but factor, especially in view of the fact that females lost weight during the experimental period, is that they voluntarily reduced food intake and hence consumed less azo dye than males. Difference in susceptibility of the two sexes to azo dye carcinogenesis has been reported by others (9), and on the basis of their findings it appears likely that had the females been allowed to continue eating the diet for a longer period of time they would have eventually developed adenocarcinomas. This point could be readily verified by further experimentation.

Addition of riboflavin analog (6, 7,-dimethyl-9 (2'-acetoxyethyl)-isoalloxazine) to the diet did not enhance the carcinogenicity of 3'-Me-DAB. It is possible that this analog did not act, under these conditions, as a riboflavin antagonist because it is fairly well established that riboflavin deficiency increases the carcinogenicity of azo dyes (1, 5). It is just as reasonable to assume that it acted as a supplement to riboflavin, since all animals receiving the analog had normal size livers free of tumors. Also, livers of females in this group were free of lesions, and livers from males deviated from normal to a much less extent than those in group 2 where 3'-Me-DAB alone was added to the diet. Thus, it would appear that 6, 7,-dimethyl-9 (2'-acetoxyethyl)-isoalloxazine exerted an anticarcinogenic effect under the conditions of these experiments. The mechanism of how it could act as an antagonist to 3'-Me-DAB remains to be elucidated, but it could be involved in the synthesis of enzyme systems that degrade azo dye. Regardless of such considerations, its apparent anticarcinogenicity here is in line with the findings of others who reported it to cause regression of established tumors in rats (7).

Summary

These studies showed that azo dye carcinogenesis can occur in rats fed a complete diet containing 3'-methyl-4-dimethylaminoazobenzene. Males were more susceptible than females. It probably would require a longer experimental period to get massive tumors with this regime compared to the procedure where azo dye is added to a semisynthetic diet low in riboflavin.

Addition of the riboflavin analog 6, 7,-dimethyl-9- (2'acetoxyethyl)-isoalloxazine to a stock diet containing 3'-Me-DAB did not enhance azo dye carcinogenesis but apparently inhibited such a process. Thus it would appear that this riboflavin analog was anticarcinogenic under the condition of these experiments. It would be interesting to test other riboflavin analogs and antagonists for their anticarcinogenicity in azo dye feeding.

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